CollageMachine:

A Model of “Interface Ecology”

By

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Dedicated to

the open minds of students and practitioners everywhere.

Abstract

Browsing is an open-ended activity, which involves fulfillment of vague desires, as well as satisfaction of definite goals. Typical computational artifacts, on the other hand, address well-formed problems. Even in the field of human computer interaction, development processes have previously been modeled in terms of users' concrete tasks. Undertaking more open inquiries necessitates exploring more open processes and methods. The interactive artifact, *CollageMachine*, which addresses browsing creatively, has been co-developed with the metadisciplinary framework of interface ecology.

CollageMachine is a creative web visualization tool that learns while you surf. Instead of waiting for you to click a hyperlink, the

program proactively pulls content of interest. *CollageMachine* supports an open-ended process of web browsing, in which the user needs only a fuzzy sense of interests. Clear advance goals are not required.

CollageMachine deconstructs websites into media elements - images and chunks of text. These media elements continuously stream into a collage. A point and click, drag and drop interface enables the user to rearrange the elements. From this interaction, an agent learns about the user's interests. It acts to shape the ongoing development of the collage on her/his behalf.

Like browsing, understanding and developing what goes on *around* computers, in addition to inside of them, is an open process without definite bounds. As a metadiscipline, interface ecology brings the perspectives of diverse disciplines to bear on the form and function of interfaces. It explores and develops the complex web of interrelationships between people, activities, codes, components, and systems. Interfaces are the multidimensional border zones through which these relationships are constituted. The dynamic interactions of media, cultures, and disciplines flow through them. Interface ecology adapts and invokes functional principles of ecosystem dynamics for the information age.

Interface ecology and *CollageMachine* co-development has connected the principles of collage with the creative cognition of emergence. A new model for hci development emanates from concept. The form of streaming visualization affords particular interactive semantics. The Collage Visualization Grid dynamically allocates screen real estate according to the agent model. A visualization of the structure of the user's interests emerges bottom up.

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Chapter 1

Roots / Motivations / Overview

Most interactive artifacts represent and support more or less closed form processes. Even editors, programming languages, and development environments are limited: while they enable authoring of works of any complexity in their target medium, they leave the burden for forming the layered building blocks of the work on the user. That is, they make the formation of sentences, paragraphs, chapters, and treatises possible, without doing much, if anything, to suggest steps one might take in the creative process. The underlying assumption is that all sense of what to say is the province of the user. Similarly, while typical browsers let the user navigate any authored hypermedia pathway, all insight regarding the choice of path comes from the user. The assumption here is that the user knows where s/he wants to go. Typical agents, like shopping bots, do work on behalf of the user, based on a precise specification of a goal. These kinds of artifacts do not support the user in wandering or playing. They don't help you transform a vague, or even latent sense of interest into a stimulating multimedia experience.

In contrast, *CollageMachine* supports an open-ended process of Web browsing, in which the user starts only with a sense of direction. Clear advance goals are not required. On-going feedback with actual media elements enables the direction to evolve. This open process is an essential part of what browsing is. Not only that, open-ended browsing is an essential part of what life is. Inasmuch as interactive artifacts are integrated with everyday life, they must be conceived in terms of the full range of activities which life encompasses. When they are so diverse, they begin to represent the cultures in which they are contextualized.

As with any artifact, the processes through which an interactive artifact is conceptualized, designed, and developed determines its resulting form and function. Usually, this process proceeds within the confines of some particular academic disciplinary structure, like computer science, of some particular corporate departmental structure, in which “marketing” defines the scope for “technology” and “creative”, or in some successful venture capital structure, in which a new corporation’s goals are defined in terms of market trends.

As the exploration which *CollageMachine* supports is open-ended, so the program, itself, was developed through an open process. I began not with a tight specification, but with a certain aesthetic sensibility, and with the potential for a certain level of scientific and technological capability. Within this space, my charter was to explore. I did not have to create something useful right away. I was able to play with ideas that I found interesting.

I conceptualized and refined *CollageMachine* through the methods of the fledgling interface ecology metadiscipline. Interface ecology brings the perspectives of diverse disciplines to bear on what interfaces are, how they work, and how they can work. It does this in a non-hierarchical way, according to the principle of equal value. No discipline dominates; none are considered subordinate. Rather, they are interdependent components, connected by flows of interaction. This “meshwork” ecosystem form supports open-ended inquiry. Thus, it enables the development of interactive artifacts, like *CollageMachine*, that support open-ended processes. The ecological approach also opens inquiry into the levels of function and context which influence the effects of interfaces. The exploration and operation of interface ecology unearths fundamental issues about the structure of meanings, knowledge, disciplines, media, cultures, and interfaces, themselves. It engages history, politics, ethnography, economics, and semiotics, as well as computer science, cognitive science, design and art.

In order to explain *CollageMachine* and interface ecology, I will begin by tracing my path in coming to develop them. This interactive artifact and its associate metadisciplinary theoretical framework have co-evolved, as part of my personal experiences. The process of their development is rooted in diverse situated knowledges, including West African drumming, the compositions of John Cage, the collages of Max Ernst, and the environmental theater of Richard Schechner. The first primary cycle of codevelopment of *CollageMachine* and interface ecology took place during the Internet boom of 1995 - 2000.

1.1. Anyako: the origin of interface ecology

I spent most of 1994 in West Africa, just prior to the Internet boom. After two months of preparations, and two in the Gambia, eight months were devoted to fieldwork in Ghana and Togo. My primary activities included studying language, traditional drumming and dancing, making audio recordings of traditional music, digital multimedia technology consulting for the International Centre of African Music and Dance, and collaborating with Francis Kofi and Melissa Lang to create the performance *Coded Messages: CHAINS.*

The ideas which have grown into "interface ecology" were conceived at the onset of my six weeks in the village of Anyako, and developed embryonically during my stay there. Anyako is in Southeastern Ghana, in the Volta Region, on the shore of the Keta Lagoon, which connects to the Bight of Benin and the Atlantic Ocean. The people who live in Anyako are *Ewe*s (pronounced Ehw-vay). They have a strong tradition of drumming and dancing. I went to Anyako, in particular, because it is the hometown of my U.C. Berkeley drumming and dance teacher, C.K. Ladzekpo.

In Anyako, I was removed from my normal context of life. I was far from the normal goings on of post-industrial America. I was away from business and family, removed from the schools, corporations, venues, and customs among which I have lived for most of my life. I was off-grid: by and large without access to electricity and telephones.[1] This provided me with a space in which to consider broad questions. "What is my work? What has it been? What do I want it to be?" Anyako was a very interesting context in which to consider these questions because of the way performance works there.

Anyako is a small village. Its inhabitants number in the hundreds. The principal source of income is fishing. The town is reachable by car, but no roads run through it, only footpaths. The tightness of the community and the absence of automobiles contributed to my sense that life proceeds on a human scale. People take time to greet each other when they walk across town. Social interactions are infused with a sense of connectedness. Anyako is emblematic of the extraordinary way performance is organized among the *Ewe*.[2] This organization permeates many levels, including media integration, flow of control or navigation, social structure, and architecture.

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[1] Actually, there is a generator there, some little electricity sometimes, a handful of televisions. But they were not in the house where I stayed, nor part of my everyday life.
[2] What follows is a somewhat abbreviated description of Ewe performance which emphasizes aspects relevant to interface ecology.

Ewe performance is powerful multimedia. Their drumming is built in terms of cross-rhythm. Cross rhythm is the “simultaneous use of contrasting rhythmic patterns within … [a single metric scheme],… a highly developed systematic interplay of varying *rhythmic motions* simulating the dynamics of contrasting moments or emotional stress phenomena likely to occur in actual human existence.” [Ladzekpo 1995b]. Cross rhythm is a cultural mechanism for composing several voices which are substantially independent and on equal footing, and at the same time, fundamentally interdependent. Among the *Ewe*, cross rhythm is a model for and paradigm of challenging life experiences. In *Ewe* drumming, cross rhythms by the master and supporting drummers engage in call and response and challenge each other. They always align tightly with an underlying pulse groundwork that is maintained by the bell and rattles, and with each other. There are also songs. The composer of the songs is called *hesino*; the song-leader, *heno*. In rare cases the songs fit precisely with the master drum; usually they float over that part, still locked in with the pulse groundwork. The dancers move in sync with the drummers. In some pieces, such as *Adzgobo* or *Agbekor*, the choreography is intricate, and tightly coupled with the master drum.[3] Dancers require special training. In other pieces, such as *Kinka*, the dances consist essentially of the “basic *Ewe*” movement, locked with the pulse and floating over the drumming episodes, like the songs. Any dancer from the

1.1. [3] In fact, I saw less of this more structured activity in Anyako than expected, given what I know of the repertoire of the Ladzekpos and George Dzikunu, another Anyako native who is director of the British dance company, Adzido. I did see an incredible performance of Agbekor in Ashiama, a suburb of Accra, the capital city. It was led by Afi Ladzekpo; most of the participants were Anyako expatriates. While much of Anyako’s traditional culture is vital, a brain drain pulls talented people towards the center. They are pulled to leave the impoverished Volta Region to seek economic opportunity. Some of them hold prestigious positions internationally as performing artist/scholars; others earn their living through other means.

community can participate. Brightly colored cloth is worn by both genders as a wrap around the waist. This display of vibrancy is an accepted form of showing-off, not unlike having a big house, but accessible to more people. Sometimes performers will wear special costumes for a particular event; more often, each will draw whimsically from personal wardrobe.

The drumming, dancing, and cloth may all be used to make proverbial statements. Proverbs are a canonized form of traditional wisdom. The drums speak through drum language by mimicking the *Ewe*'s tonal language. Drums are considered to be a "super-voice surrogate". [Ladzekpo 1995a] One proverb regarding the power of drums as instruments of communication says, "a dead animal screams louder than a live one."[4] Cloth may be printed with special graphic proverbial icons. Movements may also be vested with iconic, proverbial significance. The result is an extremely rich, multilayered form of communication. In the ecosystem terms of Francis Evans [Evans 1959], these media circulate, transform, and accumulate the energy of the community.

The structure of the music is also very interesting. For a given “piece” or “style” – and these, with a set of songs, correspond to what *I* would have called a composition[5] – there are many drumming episodes. Each episode consists of calls by the master drummer and responses by the supporting drummers. These episodes are long and extremely complex. As a series of episodes, each piece is like a symphony. However, it differs in that the order and length of the episodes is not

[4] This commentary on the power of drumming refers literally to the animal skin stretched across the drumhead.

fixed. Rather this flow of control is determined extemporaneously by the master drummer. The piece is traversed through a non-linear navigation structure, not unlike digital interaction, yet wholly analog – performed through intense, collective musical interaction. It is also significant that while much is fixed in these episodes, they also leave room for certain kinds of improvisation by both the master drummer and the supporting drummers. Thus, the drumming, alone, provides for two levels of infinite variation – structurally, through the order of the episodes and their length, and on a more micro-level, through ongoing improvisations. The options in the dancing are similar. Further, the songs usually can be selected in any order by the *heno*. They can have many possible temporal relationships to the drumming episodes. This range of mechanisms for variation in traversal results in a form that responds fluidly to the real time desires of the performers. It is like sailing the seas. Certain landmarks are constant, and yet, currents and eddies are perpetually shifting. And one will repeat certain operations, like coming about, all over the map. *Ewe* tradition stores energy in the structure of these pieces. The way they are navigated in performance transports this energy.

Among those hundreds of Anyako villagers, there are more or less dozens of performance groups. One or more of these groups organizes each performance. Performance groups are organized around a number of different principles. There are social groups organized around one or a few composers. An example is the Nobody ensemble, that was centered on the composer Besah Soku. They spun off years ago from a group called *Britannia*, whose members were part of a previous

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[5] Creation of these styles is, in general, outside the province of composers. Usually, a composer's work will be limited to creating songs that go with a particular style.

generation. *Britannia* is a style of drumming. As well as composers, drumming styles can form the basis for performance groups. *Atsia* and *Agahu* are other examples of social repertory around which groups have formed. Then there are drumming styles and associated performance groups organized around spirits, like *Yeve*, the god of thunder, and *Afa*, the god of divination. The *Gadzo* style was presented in political resistance to the colonial occupation of the British. There are also styles and associated groups that have been organized around events of state, such as *Agbekor*. In addition there are other kinds of performance groups, such as the one organized around the Amegashi, a charismatic spiritual figure.

Figure 1.1: Drummers and onlookers at an Anyako recording session of the Amegashi ensemble. The session was held in a partially constructed building at the edge of town to minimize acoustic leakage.

So there are many forms of music, and many associated forms of social organization. Some individuals perform in more than one group, but they don't usually move across these lines as blocks. Not everyone in the town is directly involved at this level, as a performer. I would estimate that almost half are.

Performances happen on many occasions. They foster rich relationships of social interaction. In the town of Anlõga, the capital city of the *Ewe*, there is an annual festival of state, *Hogbetsotso*. There are spiritual festivals; while I was in Anyako, there was a week of performances and other rituals for *Yeve*. Social groups will have performances whenever they want, just for the good time. Wake-keepings are also very important performance occasions. Through drumming and dancing, the *Ewe* help their dead pass from this world into the world of ancestors. The local schools also conduct performances. Altogether, these can add up to several performances per week. For example, on the day before our performances of *Coded Messages: CHAINS* in Anyako, two very large-scale wake-keepings occurred simultaneously. Not

Figure 1.2: A performance of *Coded Message: CHAIN*S in the Anyako town square. In the rear, some audience members sit under the *atigate*.

only are drums used at the performances, but also to announce them, and to announce other events in the town.

Architecture connects performance events with life in Anyako. One popular performance site is under the *atigate* – the main tree – in the village center. I would call this locale the village square, but you must understand there is no concrete or stone making it such, just the pattern of the space not taken by buildings. *Afa* divination and small-scale commerce also take place in this same location. They are not displaced by the event of a performance; they just move to the periphery. Other performance locations are smaller and even more integral, for example with the houses of family groups. Mapping the town, and the relationship of architectural structures to family groups, spiritual groups, performances, and other forms of social organization would make good future research.

At performances, seating is arranged to represent the community. Elders are honored with a special section. Others with special relationships to the event, social or spiritual, will also sit in special areas. Typically, the performance more or less lies in the middle of the audience, with one side clear for entrances and exits, resulting in some sort of a U-shape.

The opportunities for participation by people at a performance who are not members of the hosting performance group are multilayered. While the group will supply song leaders, in most performances, anyone who knows the material is encouraged to sing. The group will probably include designated dancers, and yet, as well, anyone who knows the choreography will be welcome to dance. In

Euramerican theater, *fourth wall* refers to the curtain, or the edge of the stage, as a barrier between the performers and the audience. In *Ewe* performance, there is no fourth wall. The interface between performers and spectators is permeable. Participation is scaffolded. It accommodates many levels of expertise, and affords learning through doing, as good educational software aspires to. The kinds of performers and performance groups, as well as the participation of other members of the community, correspond directly to the "kinds of organisms that are present; … and the roles they occupy in [an ecosystem's] structure and organization." [Evans 1959] The different kinds of performance events correspond to biological processes like photosynthesis and symbiotic exchange, which transform energy and make it accessible.

I went to Anyako to participate directly in *Ewe* performance. I studied dancing, drumming, and language there. I collaborated with *Ewe*s on *Coded Messages: CHAINS*. I will explain that deep experience further in Section 3.6.

In addition to my cherished involvement in the mechanics of *Ewe* performance, I felt compelled to consider what was going on in the village in a broad, conceptual way. I wondered, "What is different from and wonderful about not only what happens here, but how it happens, when compared to America? What can I translate and transport? And what parts of the difference come from my role as an outsider, as a border-crosser? What parts comes from traversal" I answered these questions for myself on many levels. What became interface ecology emerged from my need to answer these questions in the broadest, most abstract way – and concurrently, in specific ways, stemming from the particular contexts of my performance work, and my interactive work on the Internet.

I offer *Ewe* performance as more than a metaphor and example of integrated form and function. I identify it as ecologically constructed, because it works with and develops an open set of multi-leveled relationships, among performers, other members of the community, musical instruments, cloth, architecture, history and other aspects of personal and communal traditional life. Performative, architectural, social, and spiritual component parts are interconnected through integrated forms of composition to create an effective mechanism. This rich interface plays a key role in the ongoing evolution of community and in ongoing life in Anyako, as it also transforms individuals who participate in the moment of performance. This is an interface ecosystem.

I saw a similar connectedness in my own diverse activities, yet that connectedness was unstated and not understood by others. My earliest Anyako journal entries on the subject prescribe, "abolish[ing] the artificial boundaries between [media]," … and [establishing] direct, honest, active, give and take relationships … [to] "breathe life into the active interrelationship of participants with their surroundings." I wanted to find unifying principles, and immediately understood the contradictions of that. I was seeking a general framework that would not render diversity as homogeneous. Like cross rhythm, this frame connects independent voices through a common pulse groundwork.

1.2. interface ecology takes shape

> A [biological] ecosystem involves:
> The circulation, transformation, and accumulation of energy ... through the medium of living things and their activities…
> The processes responsible for the transport and storage of materials and energy, and the interactions of the organisms engaged in these activities…
> The kinds of organisms that are present and the roles that they occupy in its structure and organization.
>
> – Francis Evans, "Ecosystem as the Fundamental Unit of Ecology"

I returned to the U.S. from Africa as 1995 began, landing in the Ph.D. program in Computer Science at New York University. I was invited to participate in an initiative at New York University for Ph.D. study in Computer Science with an emphasis on multimedia. The Center for Digital Multimedia, as well as the Performance Studies Department and the Film/Video Department in the Tisch School of the Arts, were essential ingredients from the start.

I was still focusing, refining, and defining the integrative approach that was born in Anyako. I felt compelled to develop it further as a way of thinking and a way of working, and to practice this approach. The resonance of *Ewe* social forms was still clear in my mind. Against this internal backdrop, life in New York, and the clearly contrasting ways of working and thinking between these separate university departments, provided a swirl of conceptual fodder. Interface ecology grew in this diverse academic context.

I considered Richard Schechner's performance theory and environmental theater as prototypes. In both cases, Schechner extended the boundaries of pre-existing disciplines to create a powerful new mixture. Performance theory brought together consideration of a wide variety of performance forms – theater, shamanism, sports –

and contexts such as India and Papua New Guinea, as well as New York. Environmental theater expanded the space of performance by intentionally including the whole site of the theater. In performances such as *Dionysus in 69* and *The Tooth of Crime*, at The Performing Garage, Jerry Rojo and Brooks McNamara [Schechner, McNamara, and Rojo:1975] designed sets which included the audience in the midst of the performance. Environmental theater also elongated the time of performance, by including the warm-up period before the show started, the time during which audience members arrived, and then when they left, and the cool down period afterward. For example, also in *Dionysus in 69*, the performance began for the audience when each spectator was escorted, alone, into the theater by one of the actors. [Schechner 1994: 253]

While I was enamored of environmental theater and performance theory, it struck me that they do not go far enough. It is as if Pandora's box is opened in a brief, calculated way; then the door is slammed shut again. For one thing, what they deliver is too centered on Schechner's personal interests in certain kinds of theater and ritual. It was great that environmental theater extended performance spatially, to include the audience and their space, and temporally, to include the time before and after. But I want more. As a musician, dancer and composer, I found definition in terms of "theater" to be unnecessarily restrictive. Other media – music, dance, architecture, sculpture, and now interactivity, to name a few – deserve inclusion on the same level. Furthermore, the role of media, technology and other artifacts needs to be related to that of performance and other social activities. Most importantly, combination is not an adjunct, not just something that comes up when you consider social interactions broadly; it is key to a spectrum of works in many forms that are interesting and related. The interface is the functional zone of mixing. I will examine the objects that get mixed as semiotic building blocks in Section 3.3.1 and the methods by extending what Schechner calls restored behavior in Section 3.3.2.

"Ecology" maximally extends "environment". Artifacts, activities, underlying ways of thinking, and their environments are inseparable. The idea is to put the different aspects of locales, events and artifacts, processes and products, codes and messages, creative works and their situated contexts, all flatly on the same level in an open set of relationships. Flattening of hierarchies emerges as a theme. Evans' functional definition of biological ecosystem works as a template.

The framework that I develop in this work encompasses both the analysis of interfaces in action, and the actual building of interfaces. It establishes fundamental connections between these processes of analysis and development. I live in the thick of this interdisciplinary Pandora's Box, in the interstices between systems of representation. Interface ecology substantiates and territorializes these borders as zones of interconnection, so as to avert the marginalization they otherwise afford.

My work in different media and contexts is characterized by common characteristics. In industry, this work includes prior scientific computing "senior software engineer" positions building interfaces and architectures, such as for Boeing 7x7 commercial aircraft assembly and maintenance, and more recent work on digital branding for Fortune 50 companies. West African and Afro-Cuban drumming and dance are an ongoing artistic and ethnographic involvement. More personal syntheses and integrations include composing multimedia opera and building information environments. In response to these heterogeneous contexts, I have intuitively recognized that I encountered recurrent issues,[6] and created consistent forms.

Over and over again, I was working in regions of transition, zones between ways of thinking, territories between worlds. I was involved in translation – creating some form of understanding between people on different sides of borders. A translator is privileged in his/her role of effecting the flow of information. Both deliberately and unwittingly, my own point of view was interjected.

The borders might lie between divisions, corporations, ethnic groups, or nation-states. They enable some kinds of exchange; they form barriers to others. Different languages are spoken; different cultures are in play on different sides. Part of the job is to become fluent in these. The ecologizer working between worlds needs to understand their systems of representation – their semiotic building blocks, codes, configurations, and dynamics. This involves economic, political, social, cultural, linguistic, and media perspective. Meanings are built and deconstructed by everyday activities. I call recurrent activities which create, manipulate, and transform semiotic codes *significant behaviors.*

[6] This ongoing process continues.

One border I encountered stood between the computer security department of AT&T and the creative department of Modem Media.[7] Another fell between the villagers of Anyako and the cybernet economy. These zones are *implicit* interfaces. They are places where semiotic fascia come into contact, but which do not identify themselves as such. One emergent mode of interface ecology is the investigation of these border zones, and the contexts in which they are situated. Each of these particular implicit interfaces was occasioned by the development of a project. In addition to investigation, interface ecology also distills a generative mode of practice. Its foundation is formed by an open set of principles for explicitly creating interfaces. In the cases above, the results of interface ecology development were the architecture for a corporate "customer care" web site, and the performance, *Coded Messages: CHAINS*. So, by interface, I mean both situated contexts, that is, connected border zones where processes of traversal and translation occur, and resulting artifacts and activities, that is, myriad manifestation forms that support interaction.

In each context, the interface border zone was multi-layered, and I was traversing it. Further, this interface ecology involves mixing; it is creating new semiotic constellations built with influences and elements from both sides of a border. I am refining an open set of reusable building blocks of *inter-* work to create a framework of consistency for myself, and to make this basis for consistency available to others. Yet, these building blocks do not unify the fields; they merely serve to create crossover nodes of translation which enable interaction. They can catalyze the on-

[7] A large web advertising agency.

going formation of shifting sets of creoles, extended families of hybrid tongues. An example of this is the language of "netiquette", which has evolved through years of email, Usenet, Internet Relay Chat, and instant messaging. This tongue of FAQs and flames, which originated during the extreme geek period of the ARPANET and the Internet's pre-mass medium early days, continued to grow and evolve with the influx of orders of magnitude more "speakers" during the Internet boom. (See Section 3.7 for an ecosystem perspective on the history of the Internet.)

I have been spurred in this *inter-* enterprise by my dissertation advisor's criterion that I "create new knowledge." To uncover the patterns and structures of this work, these are repeatable results I wish to report on. I am not only proposing new disciplinary formations; with interface ecology, I am also creating a new space to support the process of disciplinary combination. Academia has responded with resistance.[8] This is not surprising. The status quo is comfortable. The grail of scientific investigation and the resistance to this fundamentally cross- or meta-disciplinary thinking with which academia at large has initially greeted me, have spurred me to refine and develop interface ecology more than I otherwise would have.

Evans' biologically rooted model of ecosystem is ripe for translation into the context of the information age. Translations of this kind are part and parcel of the border crossing experiences of interface ecology. Thus, from the start of this basis-forming, means and ends are consistent. Interactivity, performance, and other social, cultural, technological, and economic activities circulate and transform energy.

Interfaces, considered broadly, as catalytic transfer zones, are the focus of ecosystems during this period of history. The province of Chapter 3 is to develop the structure of these processes.

1.3. CollageMachine

While the conceptual framework of interface ecology was taking shape, I was also beginning to develop my next major project. As my approach to creative work is rooted in music composition and improvisation, I was thinking in those terms. Meanwhile, 1995 was the year of the first Netscape browser. The web and email grew rapidly, on "Internet time". Suddenly, the Internet was becoming a mass medium. I brought my musical sensibilities into the emerging context. I asked myself, "How will I compose in the medium of the web?" I wanted to use temporality, that is, to make a visual display which evolves over time, instead of a single static frame. I was thinking about time-varying interactivity, rather than linear animation. West African cross rhythm is a significant aesthetic logic for layering in my music. I thought I could express this cross rhythmic layering visually, as I had musically in *the economic survival rite of passage. tesrop* was an extended piece for 10 musicians, 5 actors, and 5 dancers. While you could call it opera, in my search for integrative form, I had called it "intermedia poesis".

I spent the years prior to my African journey at Wesleyan University, in the company and under the influence of composers such as Alvin Lucier, Markus Trunk, Anthony Braxton, and Ron Kuivila. The works of and conversations with Lucier and Trunk made me consider indeterminacy. For them, chance procedures applied in a

[8] Outside of New York University, where I am fortunate to receive support.

tightly structured context often play a key role in the development of a composition. Composition may begin with setting up palettes of timbres, phrases, and processes. Next, rules for selecting and combining the elements are defined. Finally, dice with appropriate number of faces are manually cast to conduct chance operations which carry out the rules. The results of each chance procedure are laboriously written out on the score. John Cage, who has written so extensively about his philosophy as a composer, is considered to be the father of this approach. While I have never been drawn to create music in this fashion, my new context, with its orientation toward the development of computational artifacts, reminded me of this more or less algorithmic approach to certain aspects of composition. Previously, I had always chosen to compose for live musicians, even if the musicians were to be triggering digital sounds through performative interfaces. Like an *Ewe*, I emphasized *feel*. Now, in considering possibilities, while composing automata for personal computers connected to the Internet, feel was not a direct option. As I drew from my bag of compositional methods, it struck me that it would be easier to create indeterminate works directly on the computer, without needing a collection of strange dice to generate random numbers. In this context, data structures which maintain state replace the written score.

Cage has been a major influence on composers and artists in many media. His works were conceptually groundbreaking. I relate to some of his aesthetics, such as indeterminacy, and his extension of "music" to include all sound. However some of our aesthetic goals differ. One point of difference is that I like to make work which is engaging. Cage was only interested in representing his philosophy; he was indifferent to the expectations of audiences. Perhaps this is why his compositions have been scorned by many classical music fans, and are not much appreciated outside of the avant-garde. A kernel of his approach finds new fruition in the medium of the web. As well as indeterminacy, Cage worked with found objects, such as using office supplies to "prepare" the piano for some of his compositions. These two methods – indeterminacy and found objects – constitute the seed which I am carrying. I trace them to his friends, the visual artists, Marcel Duchamp and Max Ernst. Duchamp created the first works that utilized found objects and indeterminacy. Ernst was a leader in developing the genre of collages which function semiotically. His works are provocative, visceral, and widely appreciated.

The Web is a great pool of digital found objects, ripe for collage. Web recombination is the process of collecting sets of these digital readymades and re-composing them to make a new interactive work. While artists such as Carmin Karasic build digital collages by hand, the technological infrastructure of the Internet provides a basis for automating this procedure. The growing pool of readymades on the web is rich with elements of popular media. High bandwidth network connections – that can quickly download extensive collections of such media elements – and powerful personal computers – sufficient to support concurrent realtime compositing and interaction – are coming into the hands of a wide sector of consumers. Web recombination can employ the channel surfing, fast cut aesthetics that are promulgated by popular media such as MTV. For these reasons, the emerging genre of web re-combiners has the potential to grow popular, and culturally significant. *CollageMachine* is an instance of this genre. Since the inception of *CollageMachine* in 1996, other Web re-combiners have been developed, such as Mandala [Helfman and Hollan: 2001], *Shredder* [Napier: 1998], Netomat [Wisniewski: 1999], and *Impermanence Agent* [Wardrip-Fruin: 1999].

So I brought the operation of collage in a musical form to the context of browsing the World Wide Web. Unlike some of the other web re-combiners, in *CollageMachine*, the operation of collage is ongoing; the collage develops continuously, over time. As in some "computer music", the composition is generated automatically, by an automata. Technologists will think of this as streaming media pulled to the user.

Every medium has its technology. Every machine has its nuts and bolts. Roller coasters have their power trains. Sound systems have their amplification circuitry. Substantial engineering and science reside under *CollageMachine*'s hood. The software engineering includes concurrency, robust network I/O, and a multi-layered Web-based architecture of Java, JavaScript, and HTML. The science breaks down into three essential functional modules: the agent, the visual designer, and the direct manipulation interface. The role of the agent is to model the user's interests and act on behalf of them. It has the semiotic responsibility to interpret the meanings of collage elements, both potential and actual, and choose interesting content. Very large, redundantly linked data structures must be maintained as part of this process. The visual designer decides how the collage will look; it makes dynamic choices about colors, sizes, and placement in order to synthesize a collage visualization of the media elements and the agent's model. The direct manipulation interface enables the user to express ongoing interest or disinterest in particular media elements, to rearrange the visual appearance of the collage, to browse, and to otherwise control the collage session. While these functional aspects are reasonably distinct, they are also interconnected by important feedback pathways. The agent informs the designer. The interface directly manipulates the visualization and feeds back to the agent. This makes *CollageMachine* adaptive.

Since *CollageMachine*'s functionality pushes beyond the realm of new users' expectations, it must promote itself through use. Not surprisingly, my usability testing data show that algorithmic sophistication, and visual and interaction design must work in concert to gain users' appreciation. This is one way that the process and product of *CollageMachine* research embody interface ecology.

I have designed *CollageMachine* as a tool, as well as a creative work. As such, I have engaged principles and methods of user-centered design. The collage is generated in response to the user. This includes the choice of content, as well as its look and feel and arrangement in her/his browsing experience. S/he needs a decent understanding of what *CollageMachine* does, in order to be able to control it. Through its design, I have tried to make *CollageMachine*'s workings illustrate themselves. Norman calls the relationship between interactive controls and their results "a mapping". [Norman 1988: 22] At the start of a session, the user directs *CollageMachine* towards initial web content. As the session continues, s/he can effect what material the collage is composed from, and how this material is visually arranged. These two functions are mapped together through drag and drop interaction. They are united in a fairly intuitive direct manipulation interface: changing the visual arrangement results in changes in the importance of related media. Usability tests indicate significant success in users' ability to achieve desired results through this mechanism. More details about the ongoing evolution of usability design in *CollageMachine*, and how users have responded, can be found both in Chapter 2 and Chapter 4.

In the process of developing *CollageMachine*, I have paid attention to matters of usability. The design and semantics of interactive controls and dynamic layout have evolved through an ongoing process of iterative development. On the broadest level, iterative development means that you build something, then you see how people respond to it, then you refine it. You continue to iterate through this cycle, until you are satisfied with the results. For *CollageMachine* development, the responses of three different audiences have been considered at different points in the development process: my personal responses as the creating artist/scientist, the responses of colleagues and friends in informal demo sessions, and formal usability tests, with standardized procedures and a somewhat broader user population.

Building a tool was a situated requirement, resulting from my position in a computer science department. A tool is "a thing (concrete or abstract) with which some operation is performed; a means of effecting something; an instrument." [Oxford English Dictionary] Tools are implements of use. Fortunately, I have been free to choose the nature and context of the operation, and from there, to solve the scientific problems which arise. My threefold charter for *CollageMachine* has been to make something which is useful, which is engaging, and which expresses my personal aesthetics, particularly my sense of composition. These disparate goals span multiple disciplines and their associated ways of thinking. Creating relationships between elements across this span is practicing interface ecology. The same range of thinking happens to be joined in harmony in the everyday, bread and butter Internet activity which, in the five short years since the first Mozilla, has quickly become an accepted part of information age life around the world: browsing.

1.4. surfing, browsing and foraging

> Waves ... are ... rhythmic swells ... containing the power of the storm which formed them ... They travel across thousands of miles... [They] display their power and beauty as they break onto the shores... The surfer connects with the wave, using it to express himself…
>
> – Liquid Stage: The Lure of Surfing

The word "browsing" comes from a 16th century French word meaning "buds, young shoots". [Oxford English Dictionary] Literally, it means "to feed on the leaves and shoots … or tender parts of rough plants: said of goats, deer, cattle. " This is an interesting activity. On the one hand, the basic need to eat for survival is being fulfilled. It is a critical task. On the other hand a culinary sense is suggested, a whimsical sense. Which shoot looks better to eat? *Next, I will browse the one which looks tastiest.*

When it comes to the web, I believe the public thinks in these terms. Hence the term, "to surf the web." Surfing, even more than browsing, is about pleasure. A surfer seeks to catch the finest wave around, and to lose her/his self in the process of riding it. S/he seeks extreme surf as a deep form of recreation, wherein self-fulfillment is derived from a sense of total involvement. [Meacham: 1994] B*rowsing* connotes similar dimensions. The pursuit of desire is connected with an open-ended sense of possibility, which derives from involvement in the traversal of new hypermedia pathways.

Unfortunately, human computer interaction researchers have typically ignored this aspect of browsing. Card and Pirolli have published a useful series of articles about how to mathematically model the web-browsing behavior of users. Later on, when I go into detail about the user interest modeling which *CollageMachine* performs, I will cite their work on *spreading activation networks*. Unfortunately and perhaps unwittingly, they have limited the scope of their work. They define their work on *information foraging* thus, "the basic idea behind information foraging theory is that we can analyze how users and their technology are adapted to the flux of tasks and information in their environment.” [Pirolli and Card: 1998] Shneiderman has similarly defined human computer interaction (hci) research in terms of making the performance of tasks more efficient. [Shneiderman and Maes: 1998] The limitations of this approach should be very clear: if you think of browsing in terms of tasks, you'll be missing a great deal of what browsing is. Like many researchers, Card and Pirolli treat this approach as if it is complete. The domain of their tests consisted of users accessing databases such as the Associated Press newswire, Department of Energy technical abstracts, and the Federal Register. There was no gurl.com, no Oxygen, Salon, or The Sporting News. Playful users are likely to forage differently than those with clear, task-oriented goals.

The problem with Card and Pirolli’s research is that they do not identify the narrowness of their conception of information foraging. While they recognize that “most of our everyday tasks can be characterized as ill-defined problems,” what they mean by this is:

> Tasks might include choosing a good graduate school, developing a financial plan for retirement, developing a successful business strategy, or writing an acceptable scientific paper. The structure of processing and the ultimate solution are, in large part, a reflection of the particular external knowledge used to structure the problem. … Costs include access, recognition, and handling costs, which can be weighed against the rate at which useful information is delivered to an embedding task. Our analyses will often concentrate on developing an understanding of the amount of valuable information per unit time that is yielded by an interface between people and information repositories. Our basic Information Foraging assumption is that people will modify their strategies, or modify the structure of the interface if it is malleable, in order to maximize their rate of gaining valuable information. A cognitive strategy will be superior to another if it yields more useful information per unit cost.
> [Pirolli and Card 1999: 4 – 5]

This does not sound like *surfing*. The values represented are all work and no play. The really fun and interesting stuff is erased. Life is more than the solving of problems, more than utility. What about heavy.com, where androgynous samurai stand as interface gate-keepers to the funky web representations of popular hip-hop and sexual personalities? It’s another world, just as important. Tasks and directed problem solving are one part of browsing; playing and free association, wandering, creative impulse and the formation of new ideas, entertainment and having a good time: all of these are browsing, too. Playing is the source of experimentation, of creativity on many different levels. Browsing includes modalities of seeking that range as wide as life experiences. Browsing is an open process. Sure, sometimes, in some contexts, browsing activities are tightly defined, goal-oriented endeavors. On other occasions, browsing is wide open blue sky. On those occasions the user does not know what s/he is looking for when s/he starts. Furthermore, sometimes goals, or more broadly, desires, evolve during the course of a browsing session.

The phenomena that Card and Pirolli have been studying do not constitute foraging at all. Foraging is rather a rough process. Foragers seek something to eat. They will be satisfied by some range of provisions. Rather, the activity Card and Pirolli describe is focused pursuit. Indeed, given the narrow range of the data sources that their subjects search, planting and harvesting might be a better metaphor. Why assume that these results can be extended to predict general surfing habits? Both opening the source space, to include the entire WWW, and opening the range of desired results, is required to address true browsing and foraging. While it is presently beyond the scope of this work, ethnographic research regarding the range of browsing activities, and associated habits, that people of varied ages undertake in different workplace, home, and public contexts, could refine insight about these issues. The breadth of the interface ecology approach provides perspective which can unpack the underlying assumptions of research contexts and compare them with prevailing culture. The use of indeterminacy and the evolution of an agent model of the user's interests in *CollageMachine* address the activities of less-focused, playful foragers. Opening the process opens the resulting products. Developers of ubiquitous computing, virtual reality, information appliances, gaming consoles, agents, and social computing, as well as media visualization tools, web sites and kiosks, must consider interfaces with an ecosystem perspective, in order to expand the range of activities that their artifacts support. Expansion of functionality will translate directly into expansion of markets.

When I was writing term papers as an undergraduate, it was my good fortune to do background research in one of the world's largest open stacks collections of books, Widener Library. It was an immense, immersive environment, teeming with books, old and new. I fondly recall free-associative flights of intellectual fancy that were triggered when I accidentally stumbled upon an interesting book – not one of the ones whose call numbers I had looked up in the catalog. Sometimes these happenstance finds were relevant to the research task at hand; other times, they were relevant only to the larger domain of my interests. I went into the stacks with well-formed goals – a topic to research, and a list of books to find. My inquiry was transformed through the process of foraging.

CollageMachine generates a potential for serendipity that is analogous to my experiences at Widener. Rather than present whole documents to the user, it breaks web pages down into their constituent media elements. It continuously chooses from the pool of available media elements and assembles its choices together into an ongoing visual composition. *CollageMachine* shifts the granularity of browsing from web pages to media elements. Foragers may be more interested in the constituent elements than in the documents, themselves. So *CollageMachine* affords a collage-eye view of the World Wide Web. It gives the user streaming collage as an alternative paradigm for web browsing. It takes some of the leg work out of foraging activities. It depends on user interaction, as expression of interests in particular media forage.

I agree partially with Card and Pirolli's underlying assumptions: I suspect that much of the time, foragers will more or less modify their strategies to maximize their rate of gaining valuable information.[9] *CollageMachine*, in fact models the value of a certain genus of information, that is, *media elements*[10]. The critical next step is to open the range of possibilities regarding what is valuable. When choosing the tender parts of rough plants, unconscious impulses mingle with directed, conscious goal-oriented steps. This research begins to analyze and to play with the behavior of users engaged in *media foraging*; future work might compare this to the behavior of purely utilitarian, focused information pursuers. Conceptual synthesis and the satisfaction of vague desires are examples of open, relatively unstructured creative processes. Creative cognition research offers some insights. I will discuss creative cognition, particularly emergence, and their role in *CollageMachine* in Section 2.2. I will talk about play and its role in interface ecology in Section 3.5.2. As a model of interface ecology, *CollageMachine* incorporates play as an important aspect of browsing, and of life. I will locate browsing in the ecology of the Internet in Section 3.7.

1.5. theory and practice

Most broadly, interface ecology and *CollageMachine* are independent initiatives that have coincidentally overlapped. The overlapping formed a relationship. At first glance, this relationship between interface ecology and *CollageMachine* is that of theory and practice. Interface ecology is a way of working; *CollageMachine* is a work.

[9] Although this will likely vary according to mood. Sometimes, foragers may be more motivated to produce results; on other occasions, they may be more content to let results come to them. The program can only do its best to model the user's intent, and perform in response. Issue of how to elicit participation are arising in my most current research, which involves situating *CollageMachine* in public ambient contexts.

Practice demonstrates theory. However, part of what interface ecology establishes is that any separation of theory and practice is artificial. C'mon baby let the interconnections roll. Not only does all theorizing take place in context, but an interface, by nature, connects.

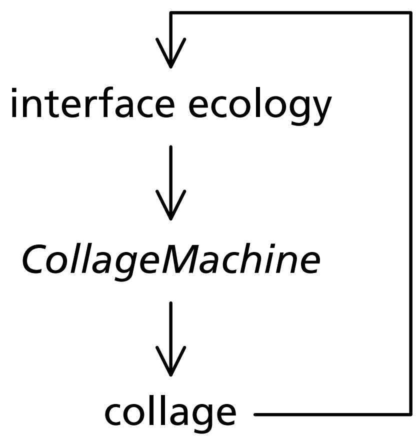

Figure 1.3 Collage turns the theory to practice conceptual flow from interface ecology to *CollageMachine* into a feedback loop.

Overlapping creates mutual influence. Feedback loops developed between the application and the theoretical framework (See Figure 1.3.). Recombination turns out to be at the heart of both. *CollageMachine* is an agent of web recombination; and the recombination of disciplines, media, and cultures, is essential to interface ecology. Both are about blending and mixing. Both are about creating hybrids. Through the approach of interface ecology, the form of *CollageMachine* developed. At the same time, the process of developing *CollageMachine* caused me to investigate the history and nature of collage. Because I was working on both at the same time, I

[10] The difference is subtle. While it's all data, *media elements* implies a wider range of expression then *information*, which sounds fact-oriented. This distinction is important: attention shifts to visceral representation.

could not help but consider collage in the context of interface ecology. The impetus to create interactive collages of web media elements, and the impetus to create conceptual collages from systems of representation, come from the same place. Collage manufactures border zones. Thus, the particulars of the *CollageMachine* project spurred fundamental initiative in the definition of interface ecology's foundation. They have mutually inspired each other, and continue to do so. Interface ecology is more than the theoretical groundwork from which *CollageMachine* sprang. Creating a loop, the utilization of collage principles in *CollageMachine* – which developed through the practice of interface ecology – also spurred interface ecology's refinement. The pivotal role of collage will be further explored in chapter 4.1. *CollageMachine* is a model of interface ecology both as an instance of it, and also as a conceptual source for it. Together this tandem, and the story of their development so far, demonstrate how theory and practice are connected through interfaces.

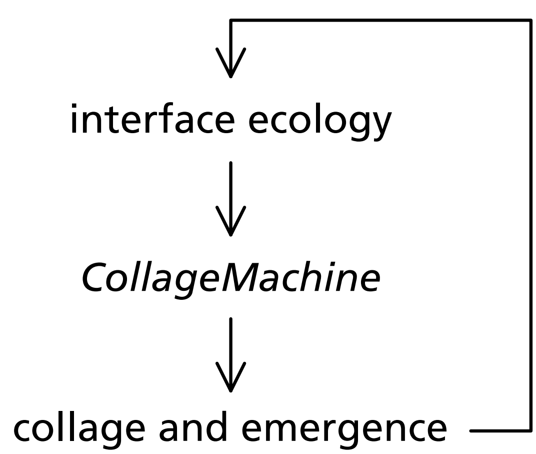

Figure 1.4: Emergence connected to collage in the conceptual feedback loop from interface ecology to *CollageMachine*.

Emergence is another key component of this feedback loop flow (See Figure 1.4.). I first learned of this topic within cognitive science and human computer interface research at Moran and Edmunds' workshop at the 1997 Computer Human Interaction (CHI) Conference in Atlanta when I went there to make a presentation about *CollageMachine*. Emergence is said to occur when new structure appears spontaneously. In studying emergence, I realized it includes scientific validation of collage. They are two perspectives on the same phenomena, which were arrived at independently, by different people, in different disciplines, at different times. To build relationships between these disciplinary perspectives is to practice interface ecology. Through the process of researching the role of emergence in *CollageMachine*, a structural inversion, or strange loop, was formed. Hofstadter uses the term *strange loop* to describe a tangled hierarchy in which following a chain of levels of reference returns us to a previous state. [Hofstadter 1979: 10] As with collage, the process of considering the role of emergence in *CollageMachine* brought

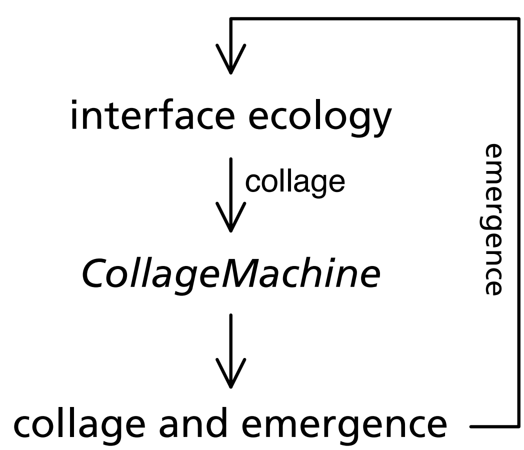

Figure 1.5 Emergence and collage as factors which operate in pathways, as well as forming a node; the interface ecology *CollageMachine* conceptual feedback loop convolves into a strange loop.

my attention to the key role it also plays in interface ecology. In other words, the role of emergence in the latter *emerged* because my research happened to juxtapose elements of the two projects; that is to say, the method of collage stimulated the emergence of this strange loop, or this strange loop of emergence (See Figure 1.5.). The continuum of referential frames between what is studied and the process of studying becomes the foundation of interface ecology and its claim to function as a metadiscipline. Connections between collage, emergence, *CollageMachine*, and interface ecology, as well as strange loops of reference, recur throughout this book.

1.6. interface ecology: a broader context

Interface ecology considers media, cultures, and disciplines in terms of their common semiotic code building blocks, that is, as instances of systems of representation. Interfaces are the border zones, connecting and separating, positioned between these semiotic systems. Interface ecosystems are characterized by highly structured exchange between particular components. What is exchanged particularly are semiotic elements, or *signs*. As human computer interfaces are one potent species of interfaces, which create openings and barriers on many levels, so there are many other phenomena based on semiotic intersection and interaction, such as diaspora, intercultural exchanges, mixed media performances, and site specific installations. The interconnecting pathways that characterize these diverse phenomena bring their reactants into mutual contact, enabling the formation of hybrids.

As constituted, interface ecology addresses an extremely wide range of issues. Schechner felt that that my proposed scope for interface ecology was overly broad, too ambitious, and so unwieldy[11]. Interestingly, early on in the development of biological ecology, the same concerns were raised about the concept of ecosystem. In the previously cited seminal 1956 essay, "Ecosystem as the Basic Unit in Ecology," Evans addressed this:

> All ranks of ecosystems are open systems, not closed ones. Energy and matter continually escape from them … The pathways of loss and replacement of matter and energy frequently connect one ecosystem with another, and therefore it is often difficult to determine the limits of a given ecosystem. This has led some ecologists to reject the ecosystem concept as unrealistic and of little use… It is also difficult to delimit a species from its ancestral or derivative species … yet this does not destroy the value of the concept.

Similarly, no one will argue about the place for individual disciplines, cultures, and media, despite their relative porosity and sporadic tendency to overlap. Vibrant border zones of translation and mixing are recurrent phenomena. They warrant sustained, focused investigation. This is the subject of interface ecology. Its research can expand the range of possibilities for interface development. In its absence, the impetus for crucial interdisciplinary work tends to get lost in the cracks between existing disciplines. No sooner does a new discipline like performance studies differentiate itself from others, then it seeks to batten down the hatches, create a canon, and define itself rigorously in a closed form. The process of innovation is undermined. While evolution may still be possible, leaps are avoided. The typical result is compression of the space of what can be explored. Further, the information age in general, with its widespread rapid transit of ideas, and human computer interaction in particular, proliferate these mixing zones. So there is further need for this attention, again with the same twin goals: to understand what is going on with

[11] Ken Perlin and Barbara Kirshenblatt-Gimblett have shared the same concerns.

networked computers in society, and to give us insight into how to innovate. This can form a foundation for the development of "next generation interfaces."

The benefits of interface ecology extend beyond my personal realization. For instance, many educators and students who are interested in multimedia interaction are often painfully aware of the gaps between the fields of knowledge they need to connect. At Tufts University, the initiative for a multimedia program is coming from diverse departments, including computer science, art history, and drama. In the absence of some kind of common ground, they have encountered difficulty in setting up courses. For example, in her multimedia course, the art history teacher Eva Hoffman found students from computer science lacked the background which enables creating a solid conceptual basis for multimedia work. In his, the computer science teacher Alva Couch, found students from art history struggled to understand and create the structures of computer programs. For them to coordinate their activities across departmental boundaries was difficult. Initially, it turned out that their prerequisites mutually excluded students in the other department from their classes. The response from many of these students on either side of the border was frustration. Over time, they are addressing students' needs by developing a more coordinated program.

An interface ecology curriculum can naturally draw from appropriate disciplines. It can explore means of connecting them. There are many possibilities for how this conceptual interface may function. What are the openings which afford connection? What is the nature of the barriers between disciplines? Institutions of multimedia education and research may serve to block and patrol, like the Great

Wall of China, or they may open the doors to a market of opportunity. The gaps between disciplines enable fertile cross-pollination. With disciplinary genetics, diverse practitioners can avail themselves of this opportunity, to transform the chasm into a lattice of connecting pathways. Interface ecology provides the needed groundwork. In its absence, the particular approaches of individual disciplines tend to dominate combinatorial processes

Another perspective is to consider that if disciplines are the corporations of academia, then where are the venture capitalists? Neither the profligacy of new interactions among systems of representation, nor their economic potential, is in doubt. Clearly, we are in a historical period – the information age, the Internet economy – typified by rapid change. How do we generate and seed new disciplinary formations? How do we engage in the biotech of ideas? The metadiscipline of interface ecology positions itself as an incubator for fostering disciplinary hybrids to meet the needs for knowledge evolution during this period of history.

The feedback loop that relates interface ecology and *CollageMachine* is similar to the one which connects interface ecology and computer science. According to venerated computer science researchers Newell and Simon, "Computer science includes the study of the phenomena arising around computers…" [Newell, Perlis, and Simon: 1967] I have heard that they made this statement to justify the inclusion of the then fledgling sub-discipline of artificial intelligence in computer science. Obviously, this inclusion is no longer in question. As computer science changed then, so may it evolve further. The study of the phenomena arising around computers is a formidable challenge. The domain of interface ecology is centered on this study. Notwithstanding that this scope as specified includes methods other than scientific ones, interface ecology is part of computer science, and computer science is part of it.

Chapter 2

CollageMachine:

A Streaming Collage Browser Learns While You Surf

People conventionally browse the web by scanning pages and deciding which links are worth chasing. They see a limited subset of all potentially interesting pages. *CollageMachine* is a supplemental browser that learns while you surf. Instead of waiting for you to click a hyperlink, the program proactively pulls content of interest. It provides an alternative information visualization for use in tandem with the hypermedia representations of a conventional browser.

This browser visualization is based on the paradigm of collage. It builds on the practices of the avant-garde artists who invented collage and employed indeterminacy. The findings of creative cognition research indicate that the methods of semiotic collage artists promote emergence and creativity both for the artist and for the audience. *CollageMachine* takes on an essential part of the creative process usually assigned to the collage artist, in order to provide the same kind of creative experience to the audience/user.

CollageMachine alters the granularity of browsing by breaking down documents. Starting from your choice of web addresses or searches, the program crawls the web. It downloads documents and decomposes them into *media elements* - images and chunks of text. These media elements stream into a collage form.

CollageMachine takes positions from both sides of the direct manipulation vs. agents debate. The user can engage in collage design as part of browsing by arranging elements for which s/he feels an affinity, and removing undesired ones. These direct manipulations are monitored by the agent component of the program, which models the user's interests. The agent develops the collage visualization on the user's behalf. A Collage Visualization Grid allocates screen real estate to optimize display of the most interesting media elements. *CollageMachine* visualizes the bottom up synthesis of emergent user interest in tandem with the top down derivation of authored structure.

Figure 2.1: *Transitions: Blue #18* by Barbara Kerne

2.1. collage

Collage is one of the most important artistic concepts of the information age [Ulmer: 1983]. Literally, collage means `glued stuff`. A good connotative synonym would be combination. That is, collage is work created by combining materials (from different sources). In most cases, at least some of those materials have not been created specifically for inclusion in the collage; that is, some of the objects were “found” or were parts of found objects. The recombination of these semiotic code elements, which occurs when they are cut from their original contexts and then pasted together, is the essence of collage.

Before getting further into the implications of what collage means and how it works, consider its mechanics. Which stuff is glued together? Where? How? The process of collage making can be broken down into four phases:

- **Selection** – the process of choosing material. This may be carried out through progressive stages: that is, first one or more pools of candidate material would be collected; then a second pass of selection would decide which materials from each pool are actually included in a particular work. This phase includes cutting, that is, separation or fragmentation of a part or parts from a whole.

- **Placement** – deciding where in a work each selected piece of material should go. Through the process of placement, the materials are removed from their prior context and transformed into elements of the collage. Special relationships are composed among the elements.

- **Treatments** – are the materials somehow processed before they are fastened? Rauschenberg, for example, sometimes puts a layer of varnish or glue over an image, so as to dull or brighten its appearance. Other examples of treatments are the fraying of edges, and the utilization of smooth cutting or rough tearing in the delineation of the borders of a fragment. In *Transitions: Blue #18*, Barbara Kerne tears fragments of prints to bring the paper's texture into her collage.

  Tearing is one of many effects that can also accomplished digitally. Such digital treatments also include filters like Gaussian blur, down-sampling, color re-mapping, and Fourier resynthesis. Details about the treatments which *CollageMachine* applies to certain media elements can be found in Section 2.7.4.

- **Fastening –** the means of assembly. Are the materials simply juxtaposed, or are they blended further? Are lines of attachment softened, or do they stick out? In *Reves et Hallucinations* (Figure 2.3), Max Ernst leaves visible pasting lines. In Paramyths, he makes them invisible. Further, when images are collaged in a print, such as in these works of Ernst's, the result may remain two-dimensional. Then again, collages of 2D works (such as *Transitions: Blue #18*) can become 2 ½ - 3 D through the piling of layers, and the fastening method, which in this case, is stitching. Or 2D and 3D elements can be combined to fill much larger spaces in installations. In *Aus Berlin: Neues Vom Kojoten (From Berlin: News from the Coyote),* Joseph Beuys assembled heterogeneous materials including toenail clippings, animal and human hair balls, fire extinguishers, a musician's triangle and striker, bundles of the *Wall Street Journal*, a hat, acetylene lanterns on sticks, and plaster rubble, filling 400 square feet. [Dia Center for The Arts: 2001] If the medium is temporal – that is, filmic or auditory – fastening includes decisions about cuts, wipes, dissolves, and cross-fades. Digitally, layers can be mixed or blended with various mathematical functions, such as the use of scaled multiplication and addition to simulate degrees of translucence and opacity. Vocoding, which maps the energies of spectral bands from one sound to another, is another example.

Figure 2.2: *Still Life with Chair Caning* by Pablo Picasso

2.1.1. *papier colle*

Braque and Picasso made the first works in the Euramerican art world that fall under the rubric of collage. This work is called *papier colle*. In papier colle, a pasted object functions within a larger work as a visual representation of some element that would otherwise have been painted. The pasted object fulfils a certain visual function by providing texture. In *Still Life with Chair Caning* (1912), Picasso used a printed piece of oilcloth to represent caning. The oilcloth was fastened with glue onto a painted canvas. It was placed in the position of the upholstery of a chair, which it represents concretely.

2.1.2. found objects

The next major advance towards collage was accomplished by the Dadaists. Dada was a movement of artists at the start of the twentieth century. They felt a need to band together without unifying in response to a perceived overrationality in society. [Lippard: 1971] They gathered at the Cabaret Voltaire in Zurich, as well as in New York and Berlin. The Dada artists were also reacting against the privileged masterworks of impressionism and early "modern" art. They began the 20th century conceptual art movement and heralded postmodernism.

Before Dada could transform papier colle, Marcel Duchamp made a related move: the practice he called "readymades." His most well known readymade was a piece called "Fountain." This was an unadorned urinal that he submitted to the Society of Independent Artists Exhibition, in New York, in1917. Duchamp described his intention for the work:

> Another aspect of the "readymade" is its lack of uniqueness ... the replica of a "ready-made" deliver[s] the same message; in fact nearly every one of the "readymades" existing today is not an original in the conventional sense. [Kostelanetz 1989: 84]

The rejection of uniqueness in the work serves to undermine the notion of privileged original in the art world. Duchamp, who had previously participated in Cubism with Picasso, did more than break away from the Cubists stylistically and conceptually with "Fountain." He challenged the way art is presented and received. The organizers of the exhibition found the piece inappropriate; eventually, they agreed to display it on a stigmatized basis – in a separate section of the hall, removed from the rest of the exhibit.

We can turn to anthropology and semiotics to decode "Fountain". According to Clifford Geertz [Geertz 1973: 5], the nature of meaning is interpretive, not objective. As such, meaning derives from the environment of presentation; from the cultural frames of reference which operate on location. "Fountain", especially demonstrated the essential role context plays in the interpretation of an artifact.[1] The same urinal which was innocuous and normal in a men's room, was outrageous in an art exhibition. Its meaning, or *semiotic encoding*, was transformed by the shift of location, or *recontextualization*. It read differently. Readymades are also called *found objects*. Their use by Duchamp grew to become the hallmark of postmodern art. Instead of creating from scratch, an artist recycles existing material which s/he finds in her/his environment.

2.1.3. Dada collage

Dada collage proceeded from Duchamp's presentation of a single readymade to the construction of assemblages of them. Found objects are a typical source for the selection phase of collage-making. While Picasso also selected the chair caning from his environment (he didn't make it), unlike the simple "Fountain", his design didn't exploit the power of context in the interpretation of signs.[2]

Subsequent to papier colle and Fountain, Duchamp's fellow Dada artists Tristan Tzara and Louis Aragon credited Max Ernst with "inventing collage". According to Ernst, "*Si ce sont les plumes qui font le plumage, ce n'est pas la colle qui fait le collage.*" That is, "While feathers make plumage, glue does not make collage." [Spies: 18] In other words, making collage goes beyond physical and visual pasting. The pasted object functions semiotically, in context, to introduce new meaning to the work in two ways. First, as with Duchamp's single readymades, the new presentation

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[1] This of course is also true when the artifact is an information appliance, or any human computer interface. The role of interpretation in the function of interfaces is considered more broadly in Section 3.3.1.
[2] More about signs in Section 3.3.2.

environment of the collage creates a new context for the interpretation of its elements. Additionally, the juxtaposition and/or mixing of elements within a collage further alters their context, and thus their meaning. It forms semiotic relationships between them.

2.1.4. indeterminacy

Indeterminacy is one means for structuring decision-making in any of the phases of collage-making. It has a long history as a cultural method, predating collage by millennia. As discussed in Chapter 1, indeterminacy refers to the utilization of chance procedures, such as random selection operations and random factors that influence the values of parameters. That is, certain creative decisions are expressed in an algorithmic form that relies partially on randomness. Work which utilizes indeterminacy is not itself entirely random: the design of the algorithm which includes random factors shapes the ultimate outcome.

The practice of indeterminacy can be traced to ancient oracles. In China, the roots of the *I Ching* (Book of Changes) can be traced to before 2000 B.C., with its use as an oracle confirmed by 1150 B.C. [Wilhem 1950: lviii – lix]. *Ifa* among the *Yoruba* people of Nigeria (later known also as the aforementioned *Afa* among the *Ewe*) and the Tarot in Europe originated during the middle ages. These oracles, while distinct in their associated rituals, are based on a core of common practices. For each oracle, a consistent set of authored elements is combined with a question that is spontaneously posed by an interlocutor. A spiritual expert invokes a chance procedure to cast the oracle. S/he then interprets the randomly selected authored element(s) in the context of the posed question.

The operation of these oracles can be explained in terms of collage, and in terms of creative cognitive principles.[3] The oracle is an engine of recombination. It uses indeterminacy to select one or more of the pre-existing, authored elements. These elements are composed together with the question, in order to stimulate the questioner and interpreter with a new semiotic combination. This combination supports the emergence of new ideas. The interpreter of the oracle is a domain expert. S/he is well-versed in the authored elements, in the general goings on of the community, and in the process of invoking the chance procedure and composing the results. Through mental synthesis and conceptual combination, the one who invokes the oracle can bring a new perspective to a difficult or auspicious situation. Future research can further develop the connections between oracles and collage in the context of interface ecology to create new interactive forms.

In its uses since 1900, indeterminacy may be seen, on the one hand, as representing the machinic processes of the industrial and postindustrial world; on the other, along with found objects, it has served as a means for destroying the notion of the privileged individual by diminishing the artists' personal voice. Indeterminacy is another means through which artists subvert the production of masterpieces, which are consumed as signs.

[3] Jung explained the *I Ching* in a different way, with the concept of synchronicity. Synchronicity takes a leap of faith to identify the results of the chance procedure as somehow occurring in empathy, sympathy, or resonance with the world conditions of the posed question.

Figure 2.3: *Reves et Hallucinations* by Max Ernst

Many of the Dadaists utilized indeterminacy. {Duchamp} Tzara created “Dada poems” by cutting up the day’s newspaper articles and casting the fragments. [Spies: 51] Ernst and Arp utilized indeterminacy while making visual collage. Ernst worked by choosing pools of found objects, from diverse sources including scientific journals, catalogues, and advertisements [Adamowicz: 27-39]. He apparently invoked chance procedures to make the next level of decisions about which materials from each pool would be selected for a given piece, and also, sometimes, about placement. Arp sometimes dropped already cut selections onto a paper from above, to effect random decisions about placement. It is less than clear to what extent Ernst and Arp allowed the results of their chance procedures to definitively determine aesthetic decisions, and to what extent they used them as an initial inspiration during the creative process, setting designs in a direction, and subsequently refining them according to personal taste.

The composer John Cage used indeterminacy more rigorously than Ernst or Arp, and with more complexity than Tzara. He was a friend of both Duchamp (who he played chess with for many years) and Ernst (who he stayed with initially when he came to New York [Cage 1961: 12] in 1942 [Sadie: 1996]. Yet he cited the *I Ching: Or Book of Changes* as his source for indeterminacy as a method. In *Music of Changes* (1951), he invoked strict chance procedures in the derivation of a score for solo piano. Another piece, *Imaginary Landscapes no. 4* (also 1951), consists of a score which instructs each of 12 performers to manipulate the volume and radio frequency knobs on an FM radio for particular time intervals which were chosen through structured chance procedures.

Cage wrote in detail about the applications of indeterminacy to music. In this regard, he distinguished composition in advance and performance as different stages in the development of a piece. He wrote about how indeterminacy can be independently applied in either stage. He illustrated the distinction with a series of examples. He invoked indeterminacy self-referentially to create a strange loop of references in this explanatory text:

> This is a lecture on composition which is indeterminate with respect to its performance… In the case of the *Intersection 3* by Morton Feldman, structure may be viewed as determinate or as indeterminate; method is definitely indeterminate. Frequency and duration characteristics of the material are determinate only within broad limits; the timbre ... given ... by the piano is determinate; the amplitude characteristic is indeterminate... The performer is free to play the given number of sounds in the range indicated at any time during the duration of the box, ... [this] method is wholly indeterminate... The function of the performer ... is that of a photographer who on obtaining a camera uses it to take a picture.
> In the *Music of Changes*, structure, which is the division of the whole into parts; method, which is the note-to-note procedure; form, which is the expressive content, the morphology of the continuity; and materials, the sounds and silences of the composition, are all determined. Though no two performances will be identical ... two performances will resemble one another closely. Though chance operations brought about the

> determinations of the composition, these operations are not available in its performance. The function of the performer in the case of the M*usic of Changes* is that of a contractor who, following an architect's blueprint, constructs a building. [Cage 1961: 36]

This passage illustrates the levels of nuance which can arise in the potential application of indeterminacy to different aspects of a process.

Unlike Ernst and Arp, Cage strictly followed the outcomes of his own chance procedures . He would never alter these outcomes to suit his own personal aesthetics, because he sought to remove personal voice from his work. He rejected the privilege of authorship and the notion that his taste was more important than anyone else's. Thus, his rigorous application of indeterminacy further developed Duchamp's program for eliminating masterpieces. Ironically, Cage's revolt against the arbitrariness of the artist's voice substituted the equally arbitrary outcomes of a machinic process. For example, the performer in *Music of Changes*, "like a contractor following a blueprint", is subjected to these outcomes. It seems that an ironic tension is created by two results of *Music of Changes* and other Cage compositions. One the one hand, whether the material is pretty or not – and he generally structured his chance procedures without concern for a pretty outcome – a composer's score which does not allow substantial improvisation, that is, one that does not include indeterminacy in the performance, imposes itself on the freedom of the performer to have her/his own ideas. At the same time, Cage's use of indeterminacy in composition creates an opening for the *listener* to have her/his own ideas, and make her/his own interpretations during the performance. This space is created because expressive classical devices such as melody and harmony are not imposed.

CollageMachine uses indeterminacy in the selection of media elements and hyperlinks, and the placement of elements in The Collage Visualization Grid. A scalar weight is associated with each object. The range of the weights is the positive floating point numbers. These weights are essential data in *CollageMachine*'s model of the user's interest regarding media elements and their associated documents. The procedural aspect of the model, that is the code, feeds this data through a series of randomSelect() operations. The weight associated with a given object effects the likelihood of its selection. The invocation of chance procedures to make key decisions links *CollageMachine* with Dada and Cage. It keeps the process open and somewhat unpredictable. *CollageMachine* differs from these predecessors in that it embodies the *process* of collage-making. As an artifact, it takes the form of an automata, rather than a single collage or composition.

2.2. creative cognition and emergence

The application of indeterminacy in creative processes turns out to be consistent with cognitive science. A group of cognitive scientists has broken off from the main line of that field in their study of creativity. The practices of these "creative cognition" researchers contribute to our perspective on collage. Previously, cognitive science had mostly limited itself to the study of "highly restricted domains" of well-formed problem solving. [Finke, Ward and Smith 1992: 5] One example is modeling people's approach to solving structured puzzles like the "Tower of Hanoi". The hope was that this would lead to insights which would then be generalizable into broader understanding of creativity. Unfortunately, limited progress was made through that line of inquiry over a period of decades.

Findings within creative cognition research explain the cognitive processes of collage. The involved researchers have included the study of fuzzier scenarios in order to cover a broad range of real-world creative practices. Through rigorous experimental investigation of what subjects do under consistent conditions, they have identified the essential stages and structures of the creative process. One of their findings is that various phenomena which are part of creativity are unpredictable. In other words, indeterminacy is a natural part of creativity. Notably, the Dada artists choice to employ indeterminacy was homologous with the very way that creativity works.

The fundamental findings of creative cognition research have been distilled into a general cognitive model called Geneplore. Geneplore breaks creativity down into phases:

- **[Generate.]** In the initial, generative phase, one constructs mental representations called *preinventive structures*, having various properties that promote creative discovery.
- **[Explore.]** These properties are then exploited during an exploratory phase in which one seeks to interpret preinventive structures in meaningful ways. [Ibid: 17]

Examples of preinventive structures include visual patterns, mental models, and verbal combinations. [Ibid: 20] The preinventive structures are precursors of creative results. But while one moves en route from generating preinventive structures to exploring them, the progression is not necessarily linear. Exploration may result in a return to the generative stage for refinement.

Preinventive structures with certain characteristics turn out to work better. Geneplore research indicates that when preinventive structures feature *preinventive* *properties*, they are more likely to lead to creative results. These preinventive properties include novelty, ambiguity, and divergence.

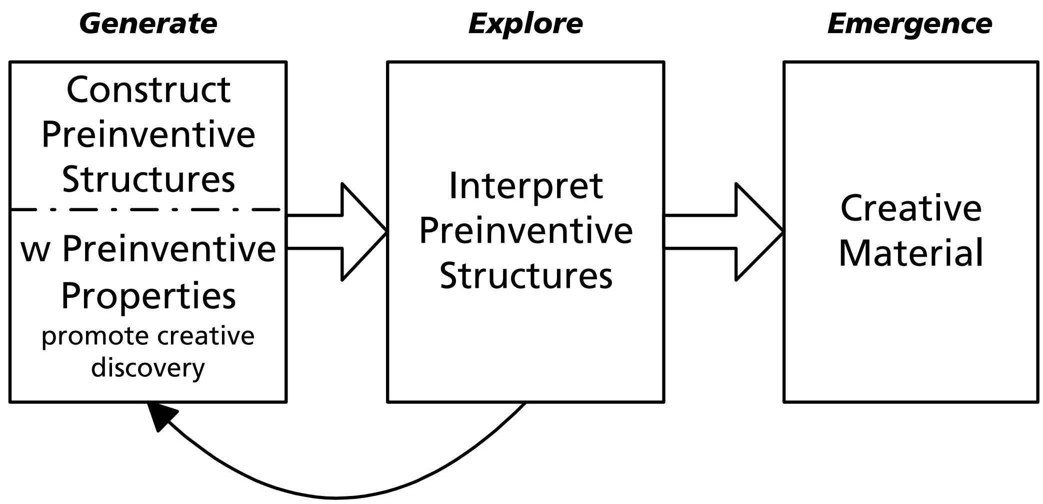

Figure 2.4: Geneplore, a Cognitive Model of Creativity

What happens next, in creative processes, after we generate and explore preinventive structures? Well, sometimes nothing, and sometimes a fascinating phenomenon known as *emergence*. In the case of a visual artist, working to create an image, Finke et al say:

> An image displays emergence when its parts or features are combined such that additional, unexpected features result, making it possible to detect new patterns and relations in the image that were not intentionally created. [Ibid: 50]

Here, combination and detection are the artist's internal cognitive processes. The example expands by substitution to describe creative processes in any form or medium. Sketching, interpreting landmarks to navigate, writing or reading poetry or essays, reading help wanted ads while seeking an appropriate job lead, surfing a wave, and even browsing the World Wide Web, …; a wide range of activities involves generation, interpretation, and the possibility for new insight, new understanding, new ideas.

Emergence is a key stage in the creative process, the sublime moment when nothing turns into something. Certain kinds of preinventive structures and properties seem to be necessary conditions for creativity. Why do preinventive structures with preinventive properties sometimes lead to emergence? Essentially, they stimulate the brain's natural drive to make sense. In the case of combinations, a person is drawn to wonder why the elements are next to each other. What do they have to do with each other? Look at Ernst's *Reves et Hallucinations* (Figure 2.3). Let me think aloud, for a moment. How are the seated figure, the woman in the bonnet above, and the military scene at his feet related? If you know that the seated figure is a reproduction of a painting of Cardinal Richelieu, how does that change your perception? The woman's head seems to usurp the cardinal's. Or maybe his body usurps her body. Some power relationship seems to be implied. I'm just looking, and trying to make connections. This is the cognitive sense-making activity through which the brain may transform the preinventive into emergence. However, the preinventive are not sufficient; there are no guarantees. Ultimately, creativity is unexpected. The experience of emergence is fundamentally indeterminate.

Typically, with regard to a work of art, we think of creativity as the province of the artist. The artist creates work and the audience receives it. However, in the collage based on more than gluing – semiotic collage – an opening is created which engages the audience on a deeper level. As this deeper level of engagement is not explicitly stated by an artist in the presentation of her/his work, some viewers find conceptual work to be inaccessible. The implicit opening is an invitation for the audience to get involved in exploring preinventive structures supplied by the artist. Different members of the audience may see different things in the work; that is, they may experience emergence in a personal way. Or, one might not experience emergence at all, in which case a likely response is, "I don't get it."

Allow me to deconstruct collage more explicitly, in terms of the Geneplore model, in order to show how collage works.

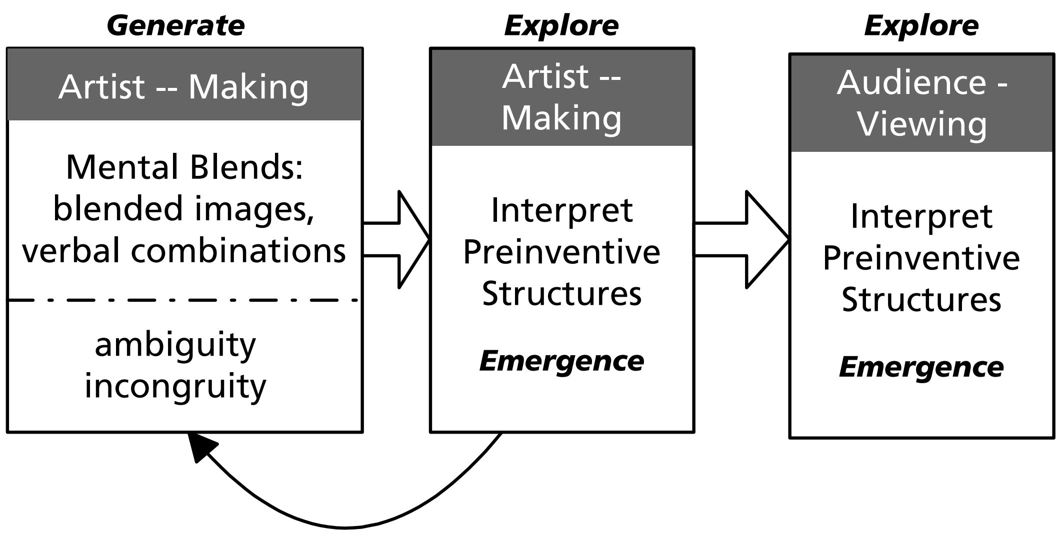

Figure 2.5: Cognition of Collage (Geneplore applied)

Within Geneplore, certain preinventive structures and particular preinventive properties describe the semiotic collage of Dada and *CollageMachine*. Mental blends are a type of preinventive structure that includes conceptual combinations, metaphors, and blended mental images. [Ibid: 22] Verbal combinations accomplish similar results, where the constituents are words. These are all based on combining processes. They are the preinventive structures of collage. Ambiguity and incongruity are preinventive properties to match with these blend structures in order to increase the likelihood of emergence. If the relationships among the combined elements are clear and definite, there is no room for the imagination, no need to engage in deep sense-making, so creativity is unlikely. The use of indeterminacy in making selection and placement decisions in collage – through its very unpredictability and arbitrariness – is likely to promote ambiguity and incongruity. In *Reves et Hallucinations*, what makes collage is the combination of elements which may evoke a multitude of vague suggestions of relationship. Apparently, the artist's intent is to offer relationships that are ambiguous and incongruous, not definite. Cognitive science has demonstrated that it is exactly this disjointedness of Dada collage that makes it so effective. Because the relationships between elements are not clear, the imagination – the unconscious mind – is spurred to fill in the blanks to make connections.

Together, these preinventive structures and properties constitute the collage artist's invitation to the audience: "Get involved in the creative process, yourself. I have not done all the work here." Figure 2.5 maps out the collage-making and receiving process. In the first stage, the artist constructs collage blends. Or perhaps, what is constructed is a process which generates the blends. Next, s/he engages in interpretation. Both particular artifacts, and their generative processes, can be interpreted. The artist experiences a certain degree both of emergence and the absence thereof in the exploration of the blends. One result is refinement through return to stage one. Construction, interpretation, and refinement may as well be conducted on the meta-level of process. For example, they may involve the tuning of procedures of selection, placement, treatment, and fastening which utilize indeterminacy.

Eventually, s/he decides that the work is ready for presentation. However, on some level the work is not complete until the audience gets involved. In the third stage – in the environment of presentation – the audience receives the opportunity to explore the blended images and verbal combinations offered as preinventive structures by the collage artist. This stage is not expected to terminate with a single interpretation. Rather, it is expected to produce an open set of possibilities. As in Finke's original definition (above), explorations during this stage are driven by a process of interpretation in search of meaning.[4] Thus, the collage offers not a single outcome, but the invitation to discover one of a multiplicity of possible interpretations. Some people who do not find the work to be engaging may miss this invitation; others may find this call to participate a burden. And of course, the Dada artists did not work because of this explanation; indeed, the rejection of explanations, altogether, was an impetus for their collages. Nonetheless, seventy years later, their methods can be understood in terms of cognitive science. The collage artist provides these structures and properties which promotes emergence. S/he conducts processes that generate work, then explores and interprets mostly on a meta level. The artist passes the concrete role of exploration and interpretation on to the audience. The results are structures which provide opportunities for the audience to experience emergence. Instead of telling a definitive story, the artist creates an environment which can provoke a different story in each audience member. Thus, this opening for the audience to experience emergence in a heterogeneous way is non-narrative.

CollageMachine positions itself within this model of the creative cognition of collage. The program takes the generative role of the artist: it constructs ambiguous and incongruous blends of images and texts. The user does the exploring. S/he can respond to the developing collage by rearranging its elements. S/he expresses interpretive sensibility through the direct manipulation interface of the collage design tools. The program monitors this interaction in order to evolve its model of the user's interests. Meanwhile, the same model drives the ongoing process of blend generation. By situating this feedback loop in the midst of the cycle of collage generation and interpretation, emergence is promoted. The structure of creative cognition is harnessed in order to assist creative experience.

2.3. direct manipulation vs. interface agents

Within HCI, there is on-going debate concerning the relative merits of direct manipulation and interface agents. Direct manipulation is said to refer to an interactive interface which puts the user in direct control of functionality. It was originally coined to refer to alternatives to command lines and programming languages. The steering wheel of an automobile is the classic example. Shneiderman treats direct manipulation as if it is an objective characteristic. In fact, in any system where all components are not physical, including all digital ones, direct manipulation is a metaphor rather than an objective reality. It is a useful

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[4] We will discover in Section 3.2.3 that this description of the impetus of the audience's creative exploration of collage – *interpretation in search of meaning* – is remarkably similar to

metaphor, and a worthy goal. As a form which combines Norman's [1988] notions of "making visible," and "giving feedback," Direct manipulation is a holy grail of user-centered interaction design.

With consideration of Maes, [Shneiderman and Maes: 1998] an agent is a program that acts on the user's behalf. It can run autonomously without direct input from the user, as well as in response to the user's direction. The actions are personalized through the agent's knowledge about the user's habits, preferences, and interests. In *CollageMachine* and other agents [Balabanovic 1998, Lieberman: 1997] this knowledge takes the form of a working model. The model collects and processes attributes of the user which are relevant to the activities at hand. Through the model, the agent makes decisions on its own volition, which constitute actions on behalf of the user. Furthermore, the agent adapts. Through the course of its operation, part of the job of the agent is to notice how the user expresses her/his habits and interests. It adjusts the model accordingly. The decision-making of the agent evolves through refinements of the model.

Advocates of direct manipulation, such as Shneiderman and Lanier, maintain that developers ought to keep the user in direct control of everything a computer does. These anti-agent-ists decry the notion that it is beneficial to posit systems in which the computer acts on behalf of the user. They challenge a fundamental assumption of agent developers: their ability to write programs which sufficiently model the user in order to make decisions which do, in fact, truly constitute actions on her/his behalf. Of course, it is true that the actions of any such agent will reflect the

Geertz's description of what ethnographers do to analyze culture.

character of its author, first, in the structure and framework of decision-making. Thus, their advocacy of skeptical caveat emptor, as a minimum, is well-founded. And the need for limits on the scope of agents should not be minimized. The decisions made by agents should not be critical ones. Human beings should not give up essential agency. Nonetheless, agents may be useful and/or amusing, especially when they incorporate the paramount goal of a good direct manipulation interface.

Advocates of agents, represented by Maes, decry the enormous complexity of information environments, like the Internet. They assert, simply, that users cannot be actively involved in everything that they need to accomplish. One reason for this is that users are unable to learn all required domain specific knowledge. Her example is that everyone has neither the time, nor the inclination, to be an auto mechanic. It strikes me that agents may get involved in activities which are desirable, as well as those that are necessary. Supporting creative processes is an example. Agents can do more than lessen the burden on users; they can augment their universe of possibilities. In either case, agents do this by acting on the user's behalf, without continuous attention.

2.3.1. interface agents

Letizia is an agent to assist web browsing, developed by Lieberman, in consultation with Maes. [Lieberman: Ibid] Letizia works by monitoring the user's interactions with a web browser, modeling her interests, exploring hyperlinks not directly chosen by the user, and suggesting web pages to explore in two small windows. One of these windows offers links, the other will display part of a retrieved web page.

Letizia is similar to *CollageMachine*. Each program monitors the user's interactions with web sites and uses these interactions to form a model of the her/his interests. Each uses its model to guide web crawling and the presentation of media of interest. Lieberman calls Letizia an "interface agent" :

> We'll define an interface agent to be a program that can also affect the objects in a direct manipulation interface, but without explicit instruction from the user. The interface agent reads input that the user presents to the interface, and it can make changes to the objects the user sees on the screen, though not necessarily one-to-one with user actions. The agent may observe many user inputs, over a long period of time, before deciding to take a single action, or a single user input may launch a series of actions on the part of the agent, again, possibly over an extended period of time.

According to this definition, *CollageMachine* is an interface agent, with more of an emphasis on direct manipulation. In the way it updates its model based on interaction, *CollageMachine* makes changes to objects which are not one-to-one with user actions. Yet, the way *CollageMachine* affords manipulation of the collage through its interactive tools gives a strong sense of direct manipulation at the same time.

The biggest difference between Letizia and *CollageMachine* is that *CollageMachine* uses the collage paradigm as a means for structuring display and interaction, and to deal with the difficult issues regarding the management of screen real estate. Letizia's two panes of recommendations can only present a few alternatives at a time. By adopting the collage paradigm, *CollageMachine* lets media elements serve as manifestations of their constituent documents (web pages). The Collage Visualization Grid provides a creative, dynamic, and efficient allocation of screen real estate, in accord with the user's interests.

2.3.2. recommender systems

Letizia uses a form of the information retrieval technology originally developed by Salton [Salton: 1983]. This works by computing the frequency of terms and in each document, and also globally. Each document, as well as the global collection, is represented as a vector of term weights. Terms which appear less often globally are better discriminants of relatedness. An inverted index allows fast access to the documents in which discriminating terms appear. A query is processed by adding the term weights for documents which contain the query terms and dividing by global frequency. This allows these candidate documents to be ranked. This approach is also used by search engines.

The design for systems like Letizia requires modifying Salton's approach. Instead of a single static "search query", a dynamic set of "queries" is formed iteratively, based on the term profiles of documents of interest. Furthermore, these queries are iteratively regenerated in response to ongoing feedback from the user. Balabanovic [Balabanovic 1998] supplies a detailed taxonomy of Salton's work, and the appropriate enhancements which are required for these "recommender systems". Balabanovic, himself, built an advanced, distributed recommender system called Fab. In Fab, the recommendations are not developed by the client, but by a server-based tier which aggregates the interest models of multiple users in order to enable community members to influence each other's recommendations.

Balabanovic suggests a combination of "exploratory" – choosing content the user has never seen – and "exploitive" – choosing content based on the user's expressed preferences – selection strategies for document recommendations. [Ibid: 7-8]

CollageMachine operates in accord with this suggestion. It uses weighed randomSelect() operations to choose content, instead of picking deterministically based on weights. This keeps the system open to including new material that the user has not expressed interest in.

CollageMachine currently does not employ the IR term frequency method for discerning the relatedness of content. Nonetheless, formal usability testing indicates that some users already perceive *CollageMachine* as a recommender system. Discussion of the need to incorporate IR technology in *CollageMachine* can be found in Section 4.3.4.

2.4. the *CollageMachine* experience – design lessons

Ah, but now," Are you experienced?
Have you ever been experienced?
Well, I have."

– Jimi Hendrix

The user experiences *CollageMachine* in two levels. The first of these levels is conventional hypermedia, presented in a standard web browser. This web level is continuous and consistent with the normal web experience. The second level is the actual interactive streaming collage; the inside *CollageMachine* experience which enables web browsing through the collage paradigm.

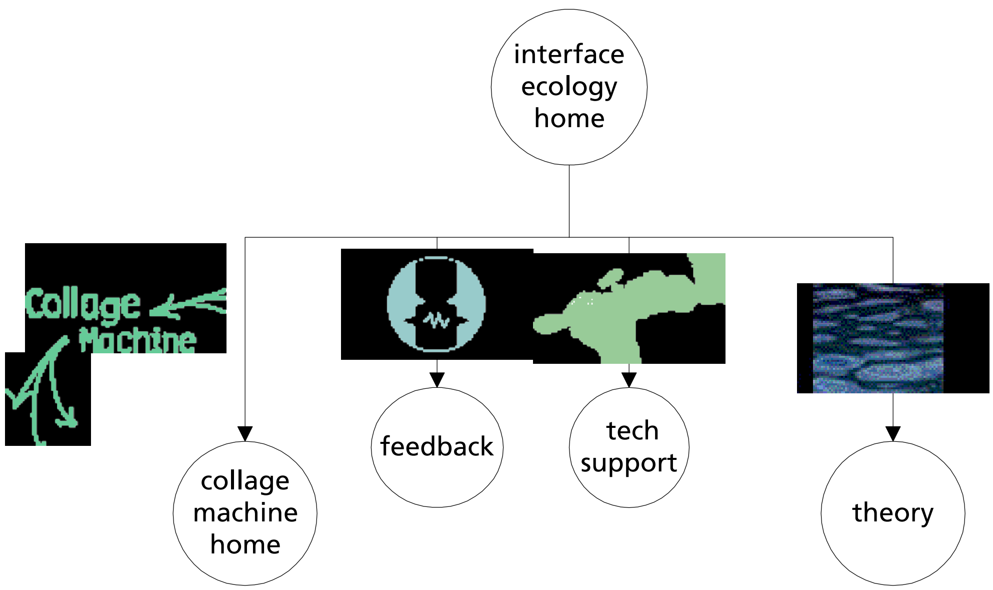


Figure 2.6 Site map component: Primary and secondary navigation from the Interface Ecology Web Home Page.

2.4.1. conventional hypermedia level

The conventional hypermedia level provides a border zone, or conceptual interface between regular web browsing and browsing through the streaming collage paradigm. *CollageMachine* is currently situated in the *Interface Ecology Web*, which begins at http://mrl.nyu.edu/ecology. The *CollageMachine* home page is directly accessible from the *Interface Ecology* home page. Other navigation paths from there include "theory", "feedback", and "tech support" (see Figure 2.6). "Theory" is the other primary content area of the site. Feedback is available from the bottom of every page in the site, as well as from inside of *CollageMachine*. It gives users an option to express opinions to developers about how the site works. "Tech support" gives users information about the site's technology requirements. The focus is on *CollageMachine*, because of its stringent requirements.[5] These tech support pages are also available in context – from *CollageMachine* launch pages – because users are likely to realize that they need such information at the moment when they try to launch *CollageMachine* (especially if it doesn't work). The other ancillary navigation paths available from the *Interface Ecology* home page are described in Appendix 1.

2.4.1.1. *CollageMachine* home

My fundamental goal for the user experience in the conventional hypermedia tier is to bring users into the *CollageMachine* experience. When they get into the interactive streaming collage, I want them to understand what is going on, why, and how to use it. Of course I also want to give them choices about the content that will be collaged when they go inside. Thus, the *CollageMachine* home page serves several functions:

[5] The current version requires a good implementation of Java 1.1.x. It is known to work on Windows in Internet Explorer 4+, and Netscape 4. It works on the Mac only in Internet Explorer 4.5, with Apple MRJ 2.1+. It probably also works on Solaris, SGI, and Linux with Netscape 4.x.

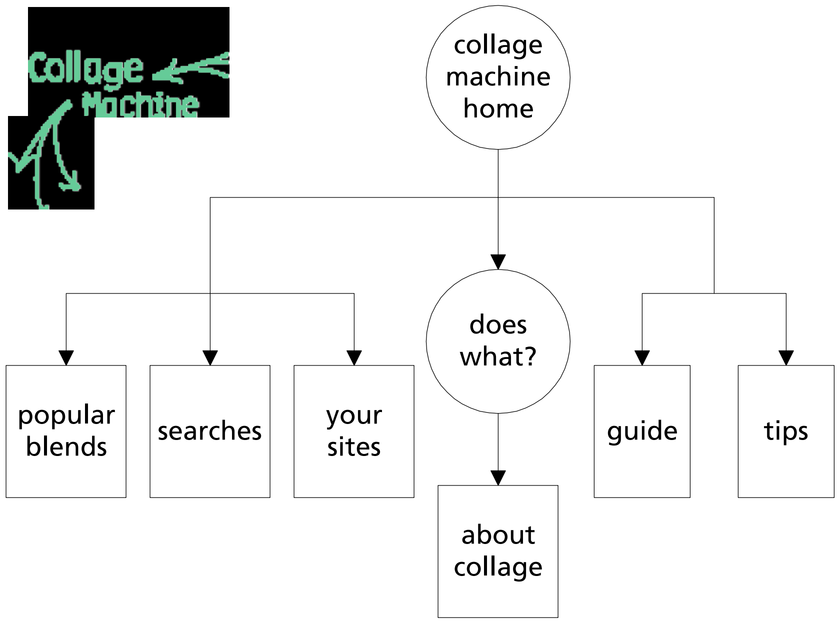


Figure 2.7 Navigation options from the *CollageMachine* Home Page.

- introduce new users to what *CollageMachine* does, and orient them conceptually so that they are able to use it;

- provide several means of access to *CollageMachine*, based on different types of seeding (popular, searches, your sites) (Seeding is described in the next section.);

- provide access to information about how to use *CollageMachine* (guide, tips); and

- provide in-depth information about the thinking behind *CollageMachine*, and about collage (does what?).

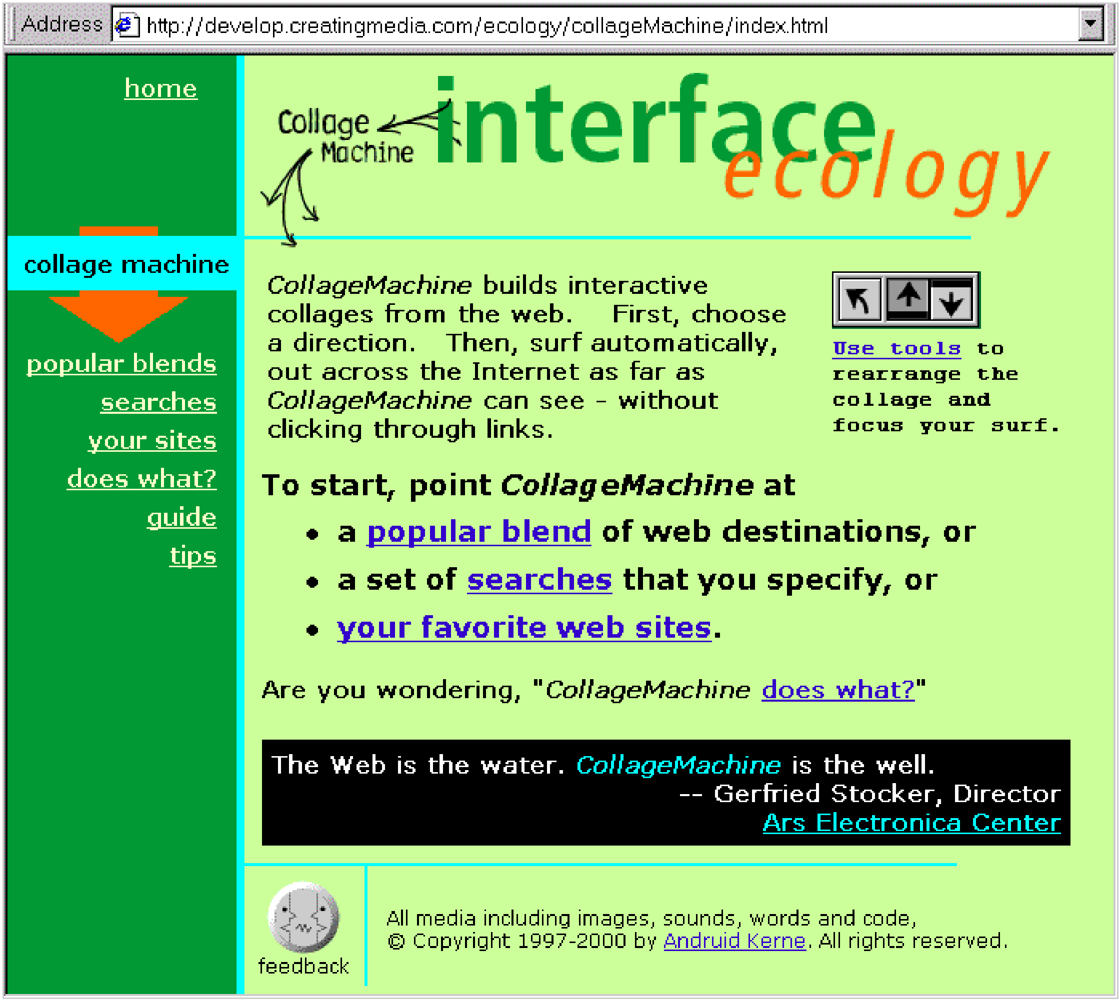


Figure 2.9: *CollageMachine* Home Page

What makes the information design of the *CollageMachine* home so difficult is that not only does it serve many functions, it also it must serve the full spectrum of users, from first time novices, to seasoned experts. These different classes of users have different needs. A single design supports heterogeneous users' experiences.

The current design of this page is the result of many iterations. That is, versions have been created and tested. Feedback from users has been gathered, and the design has been refined in response. Several design concepts for navigation and text have emerged through the iterations:

- streamline the look and feel; don't provide too much information at this level;
- be very careful about the order of explicit hyperlinks;
- assign prime screen real estate to direct *CollageMachine* access; and
- avoid jargon of all kinds; understand users in order to identify what jargon is.

There is a lot to say about *CollageMachine*: what it does, how it works, where the ideas come from, my goals in making it, and why people might want to use it. For me, it was difficult to understand what information to give users up front. It became clear both from informal and formal testing, that if there is too much information, users feel intimidated, not attracted. I have had to let go of what I want them to know, in favor what they need to know.

When there is so much to offer, navigation and text must be designed carefully. As far as navigation goes, the number of hyperlinks, their order, and their appearance turn out to be significant attributes of the layout. If too many alternative hyperlinks that refer to background information, with too deep navigation pathways, are directly accessible from this top level, many users will not find the actual *CollageMachine* at all. That is why the three actual *CollageMachine* access pages –

“popular blends”, “searches”, and “your (favorite) sites” – must be positioned center stage. These are the primary navigation options. Users can invoke them to run *CollageMachine*. Then, later, if they’re interested, they can delve into “does what?” and the now subsequent “about collage”.

Not only the number of hyperlinks, but their order, their graphical appearance, and the look and feel of the response to clicking, also require attention. In some versions with a reduced number of links, the direct hyperlink to “about collage” remained here; it was the first link on the page. Users often clicked it on their first visit. They were still prone to losing track of *CollageMachine* when following explanatory hyperlinks. While stumbling deep down this navigation pathway, they might not realize that there was actually something beyond the regular browsing paradigm to use at all.

I have designed multiple responses to the problem of losing users’ attention to supplemental material. One design solution is to put background explanations in a smaller popup browser window that likewise looks supplemental; the popup doesn’t obscure sight of the page that launched it. Another solution is to pay great attention to the order of hyperlinks, particularly explicit (i.e., text with underlining) ones.[6] That is why, in the current design, there are no hyperlinks in the opening explanation and the hyperlink to “does what?” is last. Since “does what?” is positioned at the bottom, users are unlikely to select it unless they are really

[6] I was surprised to observe that users are much more likely to click on these explicit links than on images which represent their hyperlink destinations through their inherent iconography, without graphical syntactic cueing. While this kind of “direct image representation” appeals to *me*, my design must heed the behaviors I observe in actual users.

looking for the background information it references. This way, people are less prone to getting lost in the supplemental background material.

In hindsight it seems obvious, but I was very surprised by how users are more likely to click inline text links in the order of their appearance. That is, in the user's conceptual model, the order of hyperlinks is significant. My surprise comes because in considering the conceptual design of multi-branching hypermedia graph structures, I don't see order as significant at all. In that mode of thinking, it is only the conceptual connections between hyperlinks and their references that are important. The links are a way of expanding on concepts, and expressing the rhizomatic, multi-branching graph structure of the connections between the component nodes of a whole. This had resulted in a designer's model in which only the conceptual connections of hyperlink anchors, and not their order, was considered significant. The incongruity of these two perspectives – the user's conceptual model and the design model – lead to what Norman calls a "gulf of execution". Usability testing identified this discrepancy and brought my attention to the need to address it.

Presenting documentation to first-time users is problematic. On the right side of the *CollageMachine* home page, the graphic of the toolbar and the text link below it connect to the "guide", a manual. Many users do not select this at all (I guess because of its positioning; more testing could perhaps isolate that design aspect.). Most users who do arrive at the guide only read the documentation superficially, if at all. They do not seem to want to take the time to get prepared for use; they just want to jump in. This increases the usability design burden on developers such as myself who are building web applications with complex functionality and new paradigms. A well-considered response to this need would be to offer scaffolding, that is, special help in context to novice users. This would require adding code that at least tracks usage at a workstation, or, even better, that analyzes usage and recognizes skill or its absence on the fly. Doing this effectively is a research problem in itself.

The text in the opening explanation is short and simple. It is first, but in a smaller font than the primary access, to create a clear hierarchy: the explanation is less important than the *CollageMachine* access which follows it. Experienced users can easily ignore the explanation, while novices get the background they need before they encounter the primary navigation links.

Another refinement of the explanation removed specialized terminology. A previous version of the text mentioned Dada. Some users explicitly mentioned that they didn't know what that meant and that the reference felt intimidating. This was the case in spite of the fact that I supplied a hyperlink which accessed a definition and examples. One person's intellectual staple is another's jargon.

2.4.1.2. seeding a collage

The user is offered three methods for pointing the collage at a portion of the web. The result of each of these is to specify the seed addresses which become the initial downloads that feed the collage (See section 2.6.x). One seeding method, "popular blends," offers users pre-selected sets of sites, like a typical web portal. Examples are "news collage," which draws from The New York Times, The BBC, CNN, and ABC, and “art museums,” which draws from The Louvre, The Van Gogh Museum, The British Museum, The National Gallery, and MOMA. “Searches” allows the formulation of up to five queries, which are then passed to a search engine. Most search engines produce extensive junk (in the form of unrelated shopping and advertisements). In response to formal usability tests, Google was selected as the search engine, because the results are more effective. A sub-navigation option, “multi-engine searches”, allows selection of up to 5 different search engines; in general, it doesn’t work as well as just Google. The third seeding method allows the user to type URLs directly. Usability testing showed that it is important to specify this as “web sites,” not “URLs,” because some users are not familiar with the latter term.

Users have requested drag and drop of hyperlinks to streamline seeding, and to allow additional web addresses to be passed to already running collage sessions. Implementation discrepancies across platforms have so far kept this feature out of scope.

2.4.2. interactive streaming collage level: the inside *collagemachine* experience

The user can cross the threshold into the inside *CollageMachine* experience from any of the seeding access pages. The applet makes a window for itself which takes most of the display. Screen space consists of two regions: the Collage Grid Visualization area, which occupies most all of the screen, and the control panel. A rectilinear grid is painted as the background of the whole rectangle. The collage streams dynamically and spontaneously into almost all of this area. The control panel sits on top of the grid in the lower right hand corner. The layout and appearance of the widgets in the control panel is relatively static. The graphic designer, Johanna Herget, worked with me on the iterations of the control panel design with this look and feel.[7] In a previous version, the control panel occupied a full-width rectangle at the top of the screen. That design was less interesting, visually, and less thrifty in its use of screen real estate.

[7] Herget also created the versions of the feedback icon and *CollageMachine* logo which are essential to the look and feel of the conventional hypermedia level.

2.4.2.1. static interaction - the control panel

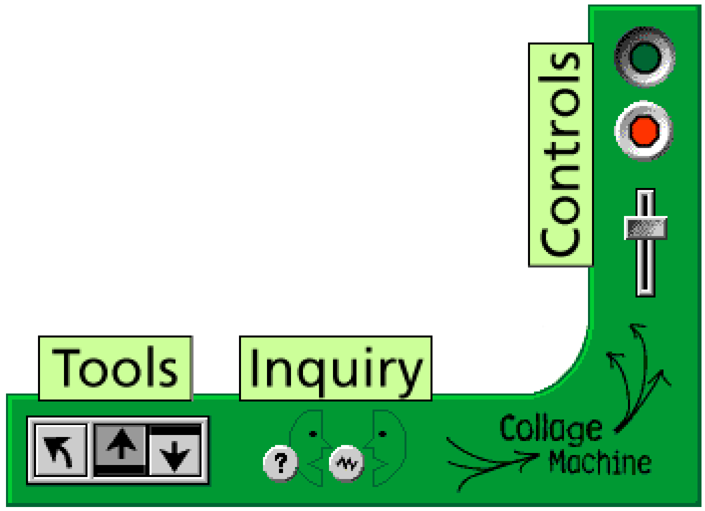


Figure 2.10 The *CollageMachine* control panel, which sits in the lower right hand corner of the grid.

Because we wanted to give the collage itself primacy in the visualization, and to make the control panel secondary, we positioned the panel in the bottom right hand corner. This was also consistent with portraying our sense of *CollageMachine* as an unconventional application. 23% of users in the formal tests had difficulty locating it down there. All of them did find it without help, eventually. This is a rare place where I am willing to knowingly sacrifice some usability in favor of aesthetics and conceptual goals. I think that its o.k. to impose a new convention on users in this way, as part of the introduction of a new paradigm. The midsection of the panel background is rounded, in order to distinguish it from collage elements. No users have yet had trouble with this, but the specter of collaging particularly confusing content[8] influences design decisions.

A short, textual help description is available for each interactive control on rollover, after a delay of a few hundred milliseconds. This functionality mimics the “tool tips” of typical Macintosh and Windows applications, including Web browsers. Approximately half of the users in the formal tests hunted for these when they were first learning the interface. Most who found one read them all.

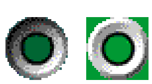
The logo, “rate controls”, “inquiry”, and “tools” make up the control panel.

2.4.2.1.1. Logo

The logo simply supplies a graphic identity for *CollageMachine*. We use it consistently at the top of the conventional hypermedia pages, as well as here inside. We wanted to express open ended possibilities, movement, and evolution. We also sought a certain grittiness, again to express unconventionality.

2.4.2.1.2. Rate Controls

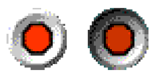
Each of the “rate controls” effects the rate of development of the streaming collage. The stop and go buttons are two state graphical radio buttons.



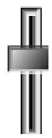
The pressed form of the go icon indicates that the application is running, that is that the collage is developing. The unpressed form

[8] Elements of the same color and shape would create visual confusion. No matter what the visual appearance of the control panel, this possibility of confusing media elements in the collage would still exist. The design can only reduce the likelihood of such a coincidence, as this design does.

affords turning it on when it is off.



The unpressed form of the stop icon affords turning the application off when it is running. The pressed form of the stop icon indicates that the application is not running.

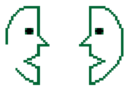


The speed slider controls the rate of collage development. In the formal usability tests, half the users discovered it. Most of those who did kept using it. The control was mostly used to slow collage development down. I have responded by lowering the default speed. I built the widget which manipulates the slider and translates its position into a proportional number. In my first implementation, it was necessary to directly grab the slider handle, itself; users often missed it. I changed it so that if you click anywhere in the bounding box of the slider and the slot, the handle snaps to your click position, and then responds to drag. When you change its position, the slider also pops up a tool tip that indicates the number of seconds between new collage elements added to the visualization. None of the tested users seemed to understand this number.

2.4.2.1.3. Inquiry

The inquiry controls are round like the start and stop buttons, but they are a different size, and are drawn with a different 3-D effect, to distinguish their functionality. They act as one-state push buttons.

This button displays a help screen. It quietly pauses development of the collage while displaying the help, so that when the user returns from the help screen (either by clicking this button again, or by clicking anywhere on the help-covered grid area), the collage is in the same state as it was when the user asked for help. Some thought has been given to going into this state automatically for perceived novice users, but nothing has yet been developed in this direction.



The goal of feedback/dialogue is to encourage users to let us know what they think about how the application works (including usability troubles and compliments) by building the mechanism directly into the application. In the limited release of *CollageMachine*, so far, this feature has received little usage. It wasn't really evaluated by the formal usability tests, since they were already based on explicit elicitation of just this kind of feedback.

2.4.2.1.4. Collage Design and Browsing Tools

The collage design and browsing tools are activated through the only square controls. These icons' shapes are distinct in order to distinguish their operation from the other controls. They are perhaps the most important elements of the control panel. They work in a manner similar to the floating toolbars of Adobe Photoshop and Illustrator, triggering the activation of mutually exclusive modes. We would have implemented them as such, except that the implementation toolkit, Java 1.x, does not support floating palettes.

Each tool activates a mode for direct manipulation of the collage. Of course, the collage consists of media elements of which documents are comprised, rather than to the documents themselves. Note that collage media elements, be they images or text, may include hyperlinks. In the case of text, the hyperlink, which is rendered in the standard underlined style, may make up only a part of the media element. In the case of an image, either the whole element is hyperlinked, or it isn't hyperlinked at all. When hyperlinked areas of an element are manipulated, the manipulations effect both the hyperlink and its source differently in the model. The hyperlink is a salient component of the manipulated object.

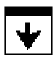
These are *CollageMachine*'s interactive tools for browsing and design, and the effect each activates for direct manipulation of the collage elements:

 **Go there.** Open a window showing a page. (If you click on a hyperlink, the page is the hyperlink reference. Otherwise it is the page that contains the media element.) Express interest in that place and in the selected element. Lift the element to the top. As a result of the usability tests, this tool is now active at startup.

The functionality afforded when this tool is active is identical to of conventional web browsers, so it conforms to the expectations of novices. This connects the collage browsing paradigm with the experience of the conventional browsing paradigm. Being able to seamlessly move back and forth between the paradigms increases the usability of the collage visualization. One half of that is currently implemented. It would be valuable to also support the reverse operation, that is, dragging of hyperlinks and media elements onto the running collage visualization from a conventional browser.

 **I Like/Grab.** Express interest in a media element and others like it. Boost their significance weights in the model (See Section 2.6.2.). Lift the element to the top. Reposition elements by dragging them. When the user starts to drag an element, development of the collage is automatically stopped. That is, the grid will

not change, except for the user's interactive collage manipulation. The rest of the visual state must be temporarily held constant, in order to share a sense of agency in the design of the collage with the user. When the user releases an element after dragging (assuming that the collage was not already stopped), the collage's development is automatically resumed.

 **I Don't Like/Cut.** Express dislike of a media element and others like it. Reduce their significance weights in the model (See Section 2.6.2.). When you click a media element, it is immediately deleted.

To economize on screen real estate, we eliminated the explicit end session control from the previous design, leaving the window system's window closing icons as the only means for ending a session. This caused usability problems for a number of users. It also violates Nielsen's heuristic evaluation criteria of "clearly marked exits." [Nielsen 1993]

Since some users attempted to use keyboard accelerators when they didn't see how else to exit the application, I implemented one for Quit, and indeed, for all interactive functions, except speed. Unfortunately, unlike on the Macintosh, where Apple-Q always quits an application, on Windows there is no consistent design guideline for how to implement this accelerator. To accommodate the situation as well as possible, in *CollageMachine*, either Cntrl-W or Cntrl-Q will now end a session.

2.5. web client architecture

From an implementation standpoint, *CollageMachine* is a client-side web application. The program was implemented as such to maximize scalability and portability. In other words, I want it to be able to run on as many computers as possible, with minimum configuration needs, and without requiring excessive hardware. The underlying software platform consists of a standard web browser (Microsoft Internet Explorer (IE) and Netscape Navigator are supported), and Java, which is distributed as a integral part of the web browser[9], as an operating system add-on,[10] or as a plug-in[11]. Keeping all execution of code on the client makes the application scalable. That is, having more users does not increase the server-side burden of execution beyond basic web serving. As of the this writing, any personal computer on the market will be fast enough to run *CollageMachine*. Memory (RAM) may be an issue: while 128M is a good idea for the current implementation[12], many PCs are still sold with only 64M, and older ones may have even less.

[9] The Java used by Netscape Navigator version 4 is distributed this way.
[10] The Microsoft JVM used by Internet Explorer on Windows, and the Apple MRJ (Macintosh Runtime for Java) which can run inside of Internet Explorer on the Mac, work this way.
[11] The only implementations of Sun's Java 1.2 and 1.3 for the standard web browsers come in this form.
[12] Actually, the current implementation is plagued by a memory leak, which (hopefully temporarily) increases memory requirements unreasonably. For more information, see Section 2.6.x, garbage collection.

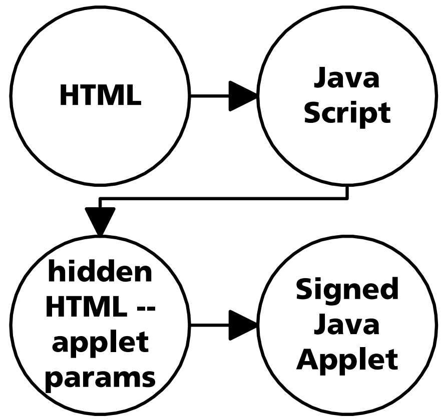


Figure 2.11 Tiered Client-side Web Architecture.

The two levels of *CollageMachine* user experience are implemented as a tiered architecture of HTML, JavaScript, and Java (See figure 2.x). The first (visible) tier of HTML implements the conventional hypermedia level of the *CollageMachine* experience that introduces *CollageMachine* to the user, and offers options for startup. Aside from providing information and transition, the primary function of this tier is to let the user choose the web addresses which seed the collage-making process. The JavaScript collects startup parameters. It then generates a hidden tier of HTML in an invisible frame, which invokes the digitally signed Java applet that implements the interactive, streaming inside *CollageMachine* experience.

2.5.1. HTML tier

All the pages in the Interface Ecology Web, including the *CollageMachine* area of the site, are implemented as framesets. On the left is a navigation frame, with a deep green background. On the right, is the content. The fundamental navigation structure of the site is a tree, even though numerous cross-links create non-hierarchical pathways. The position of each page in the tree is expressed in the nav frame (See section 2.y.). The nav frame begins with links to the list of pages above the current page, starting with the root (that is, the Interface Ecology Web home page). Then, in contrasting black text on a cyan background, comes the name for the current page. Below it, the children of the current page are listed, in the previous style. The idea of the nav is to locate the current page in the site's hierarchy. During formal usability tests, users invoked this structure less often than I expected. Improving its usability deserves further study.

The framesets for the site, including the nav frames, are generated automatically using Creating Media's Stem™ web site compiler. This 3-tier server-side application, which is invoked through a standard web browser, reads an XML description of the site tree, and generates the HTML structure from it.

2.5.2. generating HTML to launch the Java applet (seeding implementation)

A Java applet running inside a web browser is specified through special HTML tags.[13] In most cases, the parameters passed to an applet are always the same, so this can be coded by hand in a web page. In the case of *CollageMachine*, the parameters vary, depending on the seeding. In any seeding scenario, a set of URLs is generated. (Popular search engines use the CGI "get" method: the forms which call them simply collect arguments and append them as arguments in a URL.) These variable sets of URLs are passed to *CollageMachine* as start-up parameters.

[13] This is typically the <applet …> tag, followed by <param name=name1 value=value1>…, although when using the Sun Java plug-in, one must use <embed … name1=value1 …> for Navigator and <object …> <param name=name1 value=value1>… for IE.

Thus, the HTML which specifies the applet must be generated dynamically. For maximum scalability, this HTML generation implemented on the client, through JavaScript, which executes when appropriate links or buttons are pressed on the *CollageMachine* access Web pages (see Section 2.4.x). A common set of JavaScript libraries implement this functionality consistently across these pages; from a software engineering standpoint, they are included as modules with the <script language="JavaScript" src="…"></script> tags. The JavaScript might generate DHTML which would live directly inside its page of origin. The problem with this is that in the version 4-5 web browsers that are current as of this writing, the DHTML object models are horribly incompatible. So, instead, the JavaScript generates HTML which lives inside its own frame. A small frame in the lower left hand corner is reserved at the bottom of the nav frame. This frame is initially blank, except for a background identical to the background of the nav frame. This renders the frame, for all intents and purposes, invisible. The HTML for the applet assigns it a small rectangle of space in this frame.

2.5.3. Java applet tier

In the current implementation, when the applet begins to run, it paints a rectangle of green background color in the nav frame, which maintains its invisible presence there. Then it creates a new window for *CollageMachine*, based on the physical size of the display. The new window is as wide as the display, and just a bit shorter, so the user can still access other windows at the bottom of the display. This window which the Java applet creates is where the inside *CollageMachine* experience occurs. While it can easily be thought of as *CollageMachine*, really all the tiers together, including the associated conventional hypermedia experience, make up the application.

2.5.3.1. platforms

Microsoft Internet Explorer (versions 4.x and 5.x) and Netscape Navigator (version 4.x) are the supported browsers. An attempt has been made to avoid platform-specific code, in order to limit the scope of software development. The Java language platform was selected for the implementation because there are compatible implementations that run on multiple platforms. As far as delivering the applet to the user goes, the Java platform is the run-time combination of a Java virtual machine (JVM), and Java class libraries. Implementations of these are specific to an operating system and a web browser.

2.5.3.2. archive packaging and code-signing: platform incompatibilities

While the choice of Java seemed to be a prudent decision up front, in practice the platform is problematic. The devil is in the details. The quality of JVMs is one concern. The larger areas of difficulty come from the formats of Java archives, and from the privileged Java operations that *CollageMachine* must execute to do its work. Building implementation-specific archive files is required both to substantially reduce download times, and to allow digital code signing. Different archive files must be generated for each browser – a .cab file for Internet Explorer (Windows only) and a .jar for Netscape and the Apple MRJ. The Microsoft archive is about 30% smaller. Two operations performed by *CollageMachine* – opening arbitrary URLs and manipulating the state of threads – are privileged and require special security status from the Java Virtual Machine. Digital signatures are required on most platforms in order to secure these privileges. Netscape, in addition to a signature, also requires specific Java code. The code-signing certificates, themselves, as well as the tools used to attach them to the archives, are not cross-platform. These requirements are summarized in Figure 2.12. The myriad incompatible implementations of these functionalities places an enormous maintenance burden on the client-side Java developer. They substantially detract from the original criterion which motivated selecting Java as an implementation environment, cross-platform compatibility.

OS	Browser	JVM	Archive	Java Security
Windows (except 3.1)	IE	Microsoft OS level JVM – 1.1x compatible	.cab	Microsoft style RSA certificate
Windows (except 3.1)	Navigator	Symantec JVM – 1.1.5	.jar (Netscape codesign tool)	Netscape style RSA certificate + special Java calls
Windows (except 3.1)	IE, Navigator	Sun Java 1.3 Plug-in	.jar (Sun jar tool)	Sun style RSA certificate
Mac	IE	Apple MRJ 2.1+	.jar	Apple style signing
Mac	Navigator	Built-in JVM is broken	forget about it	

Figure 2.12 Platform incompatibilities for archive formats and securing security privileges.

retrieval of the already downloaded and garbage collected document becomes necessary, (relatively) slow network transmission should not be required again.

2.7. information visualization: a priori authored structure and emergent user structure

Thirty spokes share the wheel's hub;
It is the center hole that makes it useful.
Shape clay into a vessel;
It is the place within that makes it useful.
Cut doors and windows for a room;
It is the holes which make it useful.
Therefore profit comes from what is there;
Usefulness from what is not there.

– *Tao Te Ching*

2.7.1. top down derivation of a priori authored structure

A broad class of programs renders the structure of an information space and enables users to interactively walk through this structure, while dynamically updating the display to reflect the perspective from different locations within. The Xerox Star desktop, and its heirs, Apple's *Finder*[17] and Microsoft's *Windows Explorer* have done this for file systems. This process breaks down when the size of the data space gets very large, because the size and resolution of the display are fixed: it becomes impossible to render enough of the structure to provide much perspective. This problem applies to a broad range of information spaces, including maps, schematics, databases, and, of course, the hypermedia documents which make up the World Wide Web.

[17] Particularly the versions since System 7 which enable multiple folders to be browsed within a single window.

In 1986, Furnas proposed generalized fisheye views [Furnas 1986], that is, perspectives that render different parts (nodes) of an information space with different degrees of detail, depending on the degree of interest from the current point of focus, and on some a priori importance. The latter corresponds to our natural experience that some things are bigger than others. While the former is initially stated in a very general way – which could encompass subjective measures of interest, such as those which arise in *CollageMachine* – in the work of Furnas, as well as in follow-on work by others, degree of interest is actually a matter of obvious (and intuitive) objective notions of distance: wherever one is in a structure, stuff that is closer is bigger; stuff that is further away is smaller.

A number of powerful information visualization systems have been built in accord with Furnas's prescription. Fisheye Views [Ibid], The Hyperbolic Browser [Lamping et al 1995], Zoomable Interfaces [Perlin and Fox 1993, Bederson and Hollan 1994], and others provide interactive visualization of large information spaces. All of these programs are similar in that they essentially take a pre-existing structure and render their visualizations through a top down walkthrough which recursively parses and renders. They add the perspective of the location of the user's focus. Some applications may allow editing of the structure. It may be possible to add nodes, and even to move branches or sub-graphs. So, give or take the ability to make incremental structural changes, and see them immediately integrated into a view, what this family of applications – at least so far – derives are top down interactive visualizations of authored structures. These applications use temporality in spurts, in the form of animation to effectively express transitions in the user's point of reference, in response to navigational interaction. Unlike in *CollageMachine*, there is no streaming. There is no agent taking proactive steps, nor sense of music composition. Without the user's interaction, the visualization is static.

2.7.2. bottom up inference of emergent user interest structure

Instead of representing only the authored structure of documents, *CollageMachine*'s interactive visualization conjoins the user's interests with the documents" contents. Another difference from the top down visualizers is that *CollageMachine* moves across the boundaries of authored structure to mix representations of multiple webs.

Consistent with Furnas' suggestion, *CollageMachine* assigns a degree of interest, or *interest weight*, to each element. In generating the visuals that derive from a single source, the program's internal operation is similar to the top down tree and graph systems: it begins with some root node – here an initial HTML document – and then works recursively by traversing emanating edges – hyperlinks, in this case – in a structure-building parsing operation. Here the parse feeds the collections of media elements and hyperlinks which are sources for the collage. Like the top down structure visualizers, it also maintains an internal data structure (a directed graph) which represents the structure of each document and its relationship to others in the larger web. In this structure each node represents a web page. A node contains a list of media elements and a list of hyperlinks. Each hyperlink refers to another page, forming the directed graph. As a session progresses, each node also gets annotated with the significance weight and various state information, such as the progress of parsing, visualization, and eventually, garbage collection.

As described in Section 2.6.4, *CollageMachine* uses the collection of media elements, their weights, and the hypermedia graph's structure to drive the operation of The Collage Visualization Grid. The structure visualized by *CollageMachine* conjoins a model of the user's interests which emerges through bottom up inference with the authored documents' top down structure. The visualization of the directed graph is indirect. Where the interactive structure visualizers render the structure of the documents as authored in a top down fashion, in *CollageMachine*, contrary to the direction of the parsing operation, the visualization based on the evolving significance weights proceeds bottom up. By engaging in collage design (The interface is described in Section 2.4.2.), the user can express interest and disinterest in media elements, and thus in the documents and hyperlink pathways that they represent. The Collage Visualization Grid (See Section 2.6.4 for details.) dynamically allocates screen real estate based on the weight associated with each media element: the more important the program thinks an element is, the stronger its claim to hold space on-screen. This effects an efficiency of space allocation which is driven by the user in a manner analogous to the focus-driven weighting of fisheye views.

At first glance, *CollageMachine* does not seem to visualize structure at all. First time users are initially struck by the randomness. Yet, during usability testing, 92% of users were attracted to the collage form and said they would be likely to use it. 62% of them were able to use the existing direct manipulation facilities to effectively steer collage sessions toward content of interest, On reflection, the *Tao Te Ching* can be applied: where the top down visualizers show the detailed structure of a wheel's spokes, *CollageMachine* visualizes the space between them from the user's point of view. "From what is not there," through the user's subjective gaze, useful structure emerges.

Future research might conduct usability tests which compare users' satisfaction levels using *CollageMachine*, the *Inxight Hyperbolic Tree*, and a standard browser. The tests should include various degrees of directedness in the activities users are asked to perform, ranging from a search for something very specific, through vague, fuzzy somewhat directed browsing, to completely open channel surfing scenarios. They also need to include a range of users: users whose disciplinary backgrounds and interests and levels of education vary. It would also be beneficial to test users in different places: at work, in cafés, and at home

2.7.3. emergence in the collage visualization grid

In *CollageMachine*, visualization of the directed graph of the web is indirect. The collage is a preinventive structure of blended images and verbal combinations. Degree of interest is inferred in the agent model through a bottom up process which responds to interaction. The structure of the visualization evolves. In contrast with the directly derivational and deterministic operations in the top down visualizers, the use of inference and indeterminacy in Collage Visualization Grid computations interjects ambiguity and incongruity. As the user's ongoing feedback about significance adjusts the weights, her/his interests drive the process as much as authors' senses of connection and importance. And the weights are not rendered precisely. The preinventive structures and properties which enable emergence are fostered.

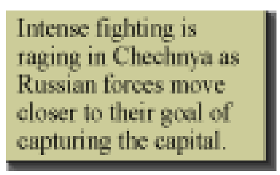
2.7.4. model visualization – dynamic interest-wear treatments

The better the user understands CollageMachine's model of her/his interests, the more able s/he is to use the program effectively. CollageMachine provides an on-going visualization of the state of its interest model. The program learns about the user from interaction. By observing changes in this visualization, the user can engage in the complementary process – to learn about the program and its model through interaction.

CollageMachine's model visualization annotates collage elements with their model states. Hollan and Hill call an object which includes information about how it has been used in its visual representation a *history-enriched digital object.* [Hill and Hollan 1993] History-enriched objects display graphical abstractions of their accrued interaction histories. Thus, these objects are used in the context of their own interaction histories. An example is a "attribute-mapped" scrollbar with an embedded bar graph inside that indicates how many times each spot in a long document has been visited. They call this *read-wear*, and contrast it with *edit-wear*, which indicates how many times each spot has been changed.

CollageMachine history-enriches the media elements it displays as part of the collage, with a graphical annotation that could be called *interest-wear.* As I've previously mentioned (See Sections 2.a.b and 2.c.d), the user can express interest and disinterest in collage elements using the interactive design tools. Through the application of the spreading activation network, these expressions are propagated to related elements. To support this process, for each collage element, the agent model includes a variable which tracks the magnitude and sign of interest. Direct manipulation of an element will change the value of this variable; it may also be changed by inference from the direct manipulation of another element.

Any collage element for which the model indicates some sense of dis/interest (that is, this variable is nonzero) is displayed with an interest-wear collage treatment (See Section 2.1.), or *decoration.* These decorations provide a further bottom up, inferred visualization of the information space, based on the user's degree of interest. While the model is implicitly rendered through the operation of the Grid, this interest attribute is also explicitly rendered through these decoration treatments. These treatments history-enrich the collage elements with a dynamic visualization of the sense of interest. Through this mechanism, the agent tries to give the user insight into what's going on with its model.



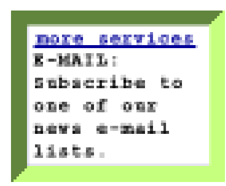


Figure 2.13 Collage elements with history-enriched treatments. On the left is an I like element with a black and white drop shadow. On the right is a disliked element, with a complementary bevel.

The appearance of the interest-wear treatment is different, depending on whether the model indicates that the user likes or dislikes the element. In either case, the width of the decoration is proportional to the magnitude of the variable. When, according to the model, the user likes an element, the decorative treatment takes the form of a black and white drop shadow. The drop shadow is rendered below the element, and to its right. When the user dislikes an element, the decorative treatment takes the form of a 3D bevel, rendered on all sides of the element. The bevel is assigned a hue complementary to the background of the element. This means that if the element actually displays much of its background color (The program is unable to know whether it does.[18]), a strong, contrasting color harmony will be created. Note that in some cases, the hue of an element's background is indeterminate. This occurs when saturation is zero, that is, when the element is white, black, or a neutral gray. For documents with such a background color, *CollageMachine* assigns an arbitrary hue. This is done only once, on a per site basis, to maintain the visual consistency of the model. The disliked element in Figure 2.13 is an example of this.

2.8. *CollageMachine* session example

State 1

Early stage of a news collage session. A few elements have appeared. Grid space is being filled gradually. Slight overlap of two elements is possible because weighted randomSelection(), rather than a deterministic minimum seeking algorithm, is invoked for placement.

State 2

Same collage state. No new elements have been added because the stop button is depressed. The user has just selected the youths with arms folded image element

[18] Specifically, if the media element is a text chunk, or a GIF image that happens to be transparent, the background color will be substantially displayed. Otherwise, it may not be visible at all.

with the “Grab / I like” tool. The program has responded by adding an interest-wear decoration to it.

State 3

The collage continues. The story associated with the image turns out to be about the role of youth in the recent Serbian revolution. Many images and texts from that story have been added to the collage. Each of them is similarly decorated with an interest-wear drop shadow to indicate that the agent believes the user likes them.

State 4

Same collage state. No new elements have been added because the stop button is depressed. The user has just selected the Gore/Lieberman image element with the “Grab / I like” tool, and dragged it towards the center of the collage. The program has again added an interest-wear decoration. The weights of this and related elements are increased.

State 5

The collage continues. New Bush/Gore election story images and texts are added. Existing ones have percolated upwards in the stacking order. Already existing elements from the Serbian story continue to garner prominent placement in the Collage Visualization Grid, because while the weights of Bush/Gore elements are increased, the Serbian story elements pretty much maintain their weights (except due to the slow effects of the aging algorithm). Thus other elements of the collage are far more likely to get replaced. For similar reasons, some new Serbian story elements have also been added to the Grid.

The current version maintains the weights of these sets of elements independently. Thus, it is able to track the two expressions. However, it is hardly aware, for example, of distinctions such as the intersection of the interests derived from the two queries together. This is partly a matter of the lack of IR term frequency analysis in determining the relatedness of elements. The lack of this distinction is also a matter of the visualization not particularly indicating particular expressions of dis/interest. It only aggregates them as overall interest weights. Experimentation with different forms of interest-wear visualization which do indicate how weightings correspond with different manipulations performed by the user is another interesting area for future research.

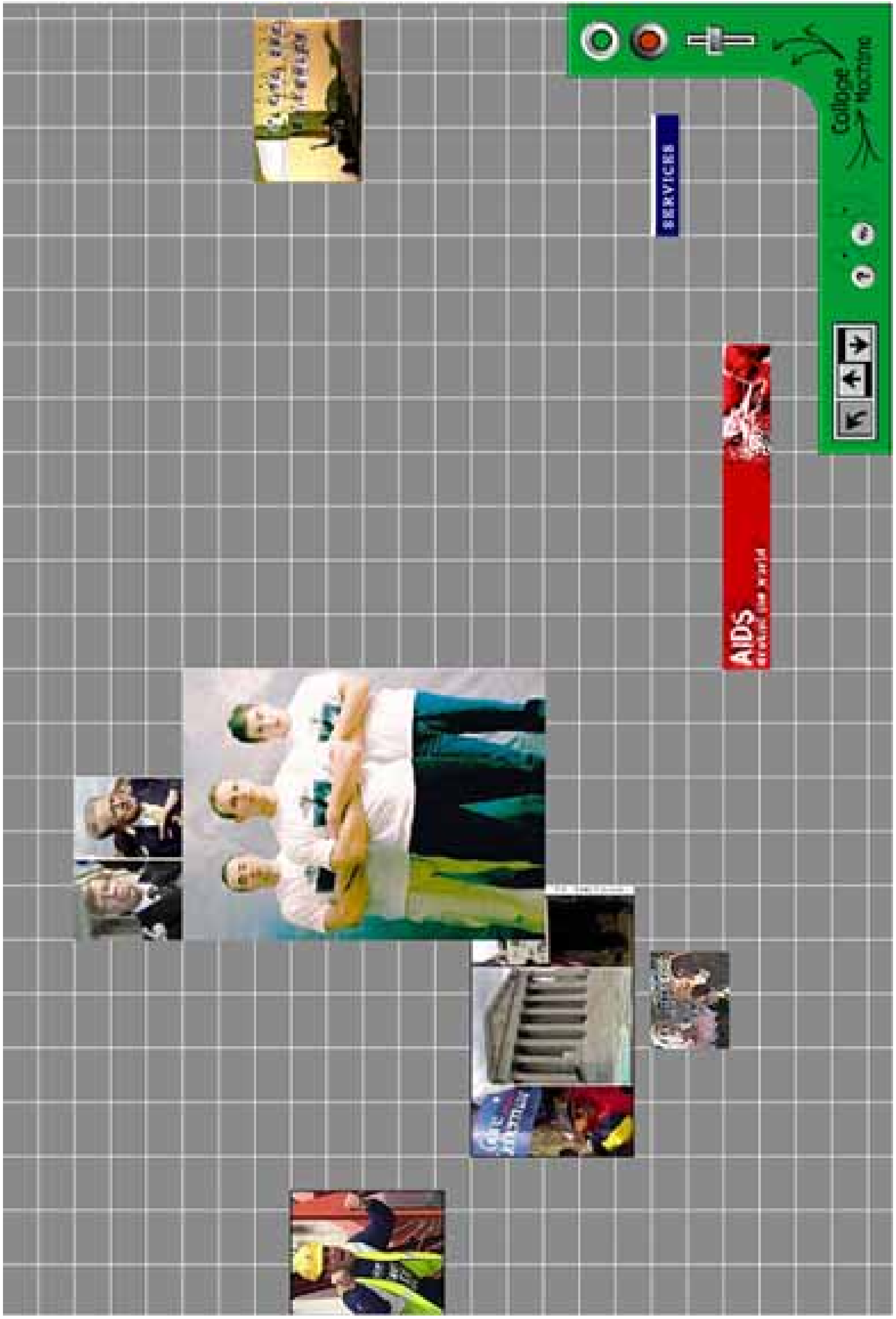


Figure 2.14 News Collage State 1 Early stage.

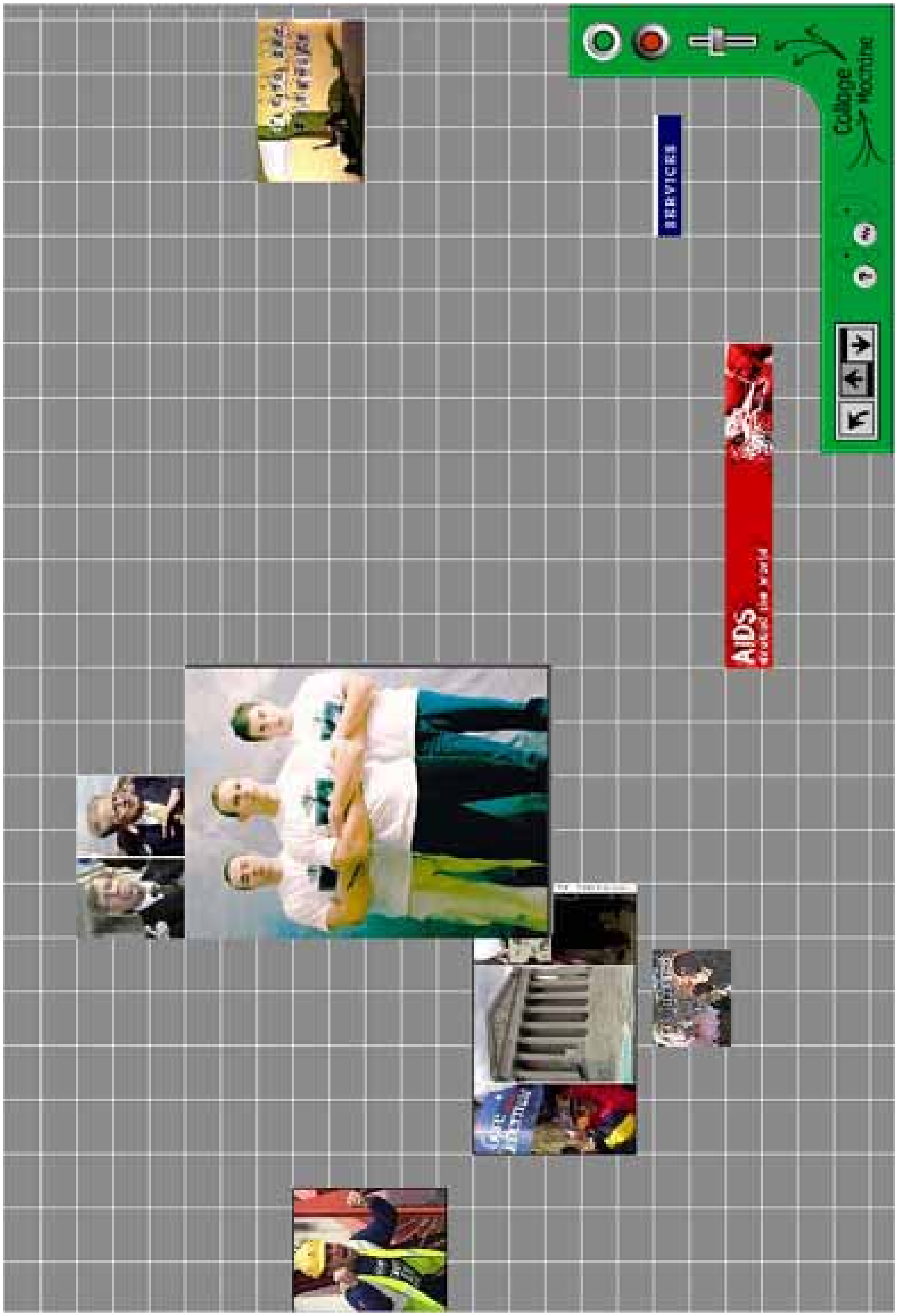


Figure 2.15 State 2: Same collage. User has selected youths element with "Grab/I like. Program adds interest-wear decoration.

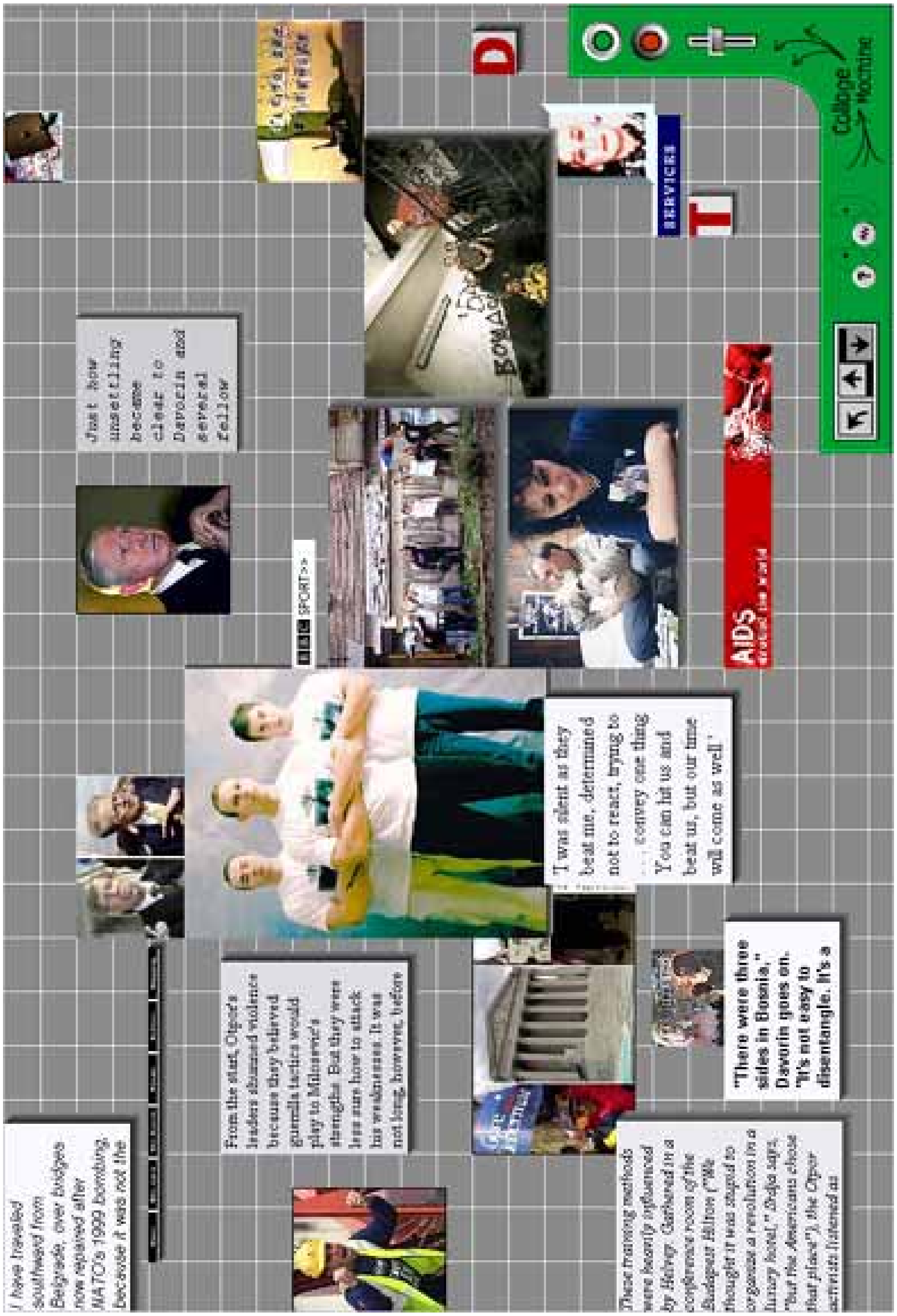


Figure 2.16 State 3: Collage continues. Related elements are added, with corresponding interest-wear decorations.

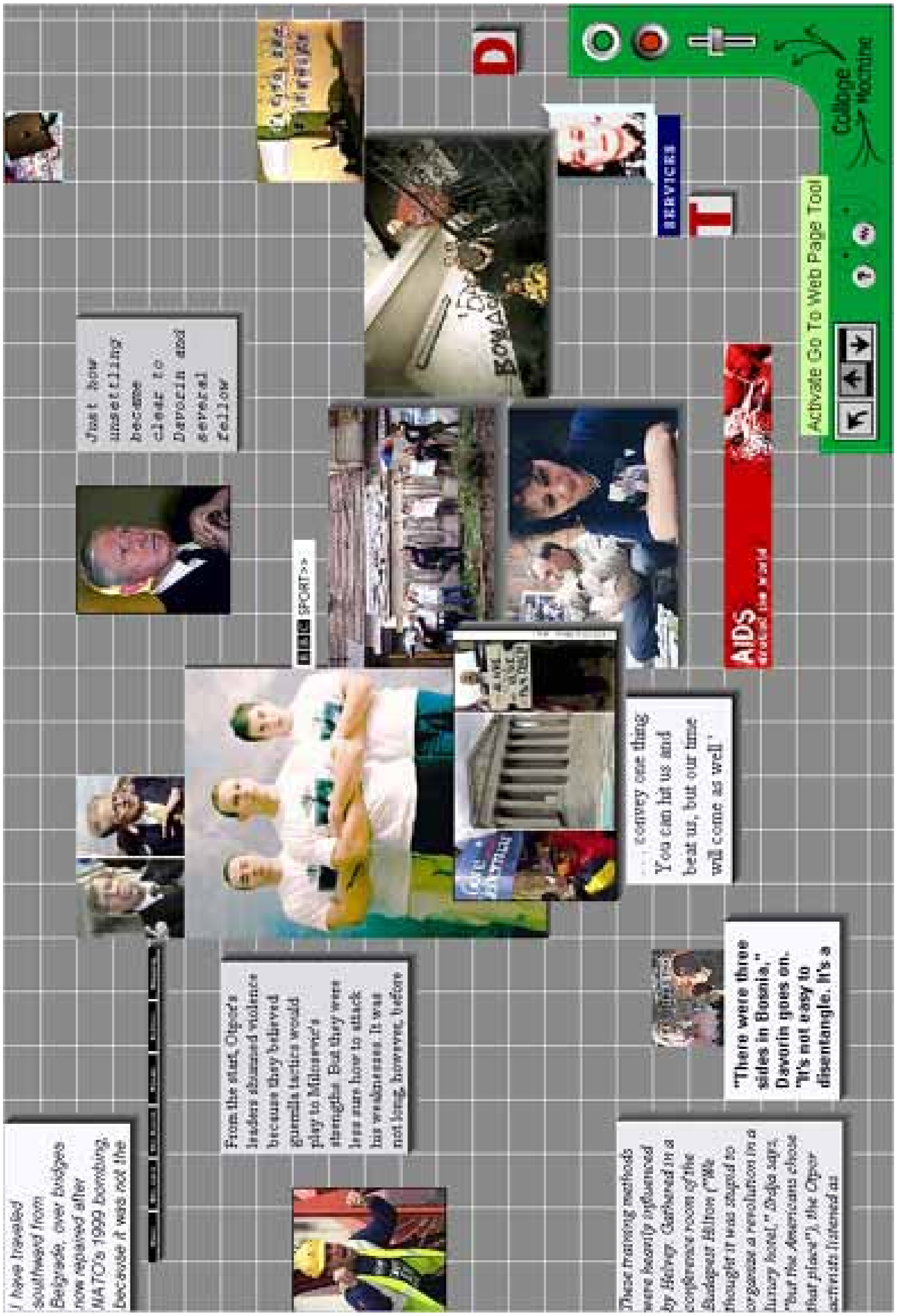


Figure 2.17 State 4: User selects Gore/Lieberman element with "Grab / I like";drags it towards center.

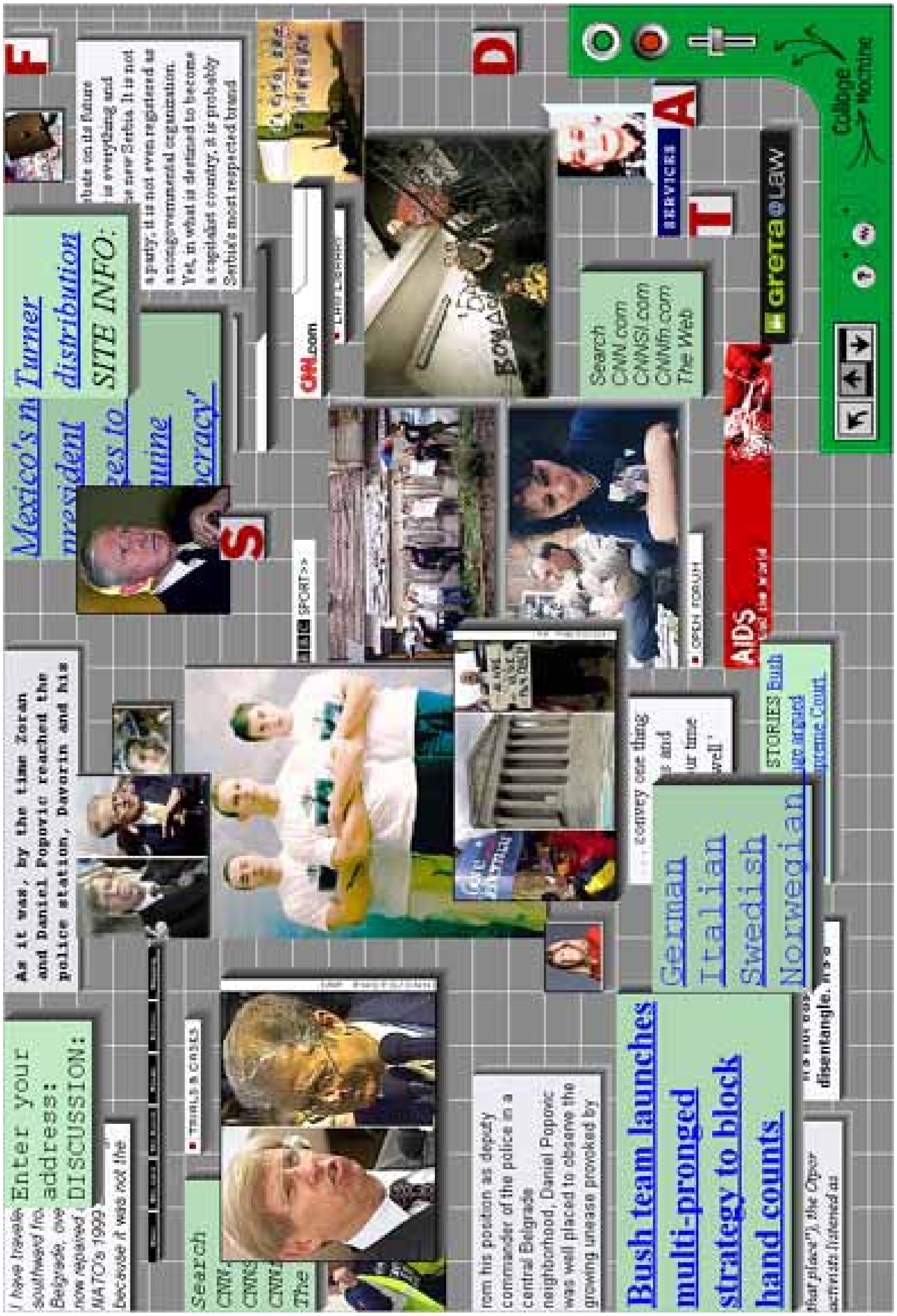


Figure 2.18 State 5: Collage continues. New Bush/Gore election story images and texts are added. Existing ones percolate up.

Chapter 3

Interface Ecosystem as the Fundamental Unit of Information Age Ecology

(or Interface Ecology: Dynamic Relationships in the Border Zones Where Systems of Representation Meet)

With regard to life on Earth, ecology investigates the web of relations between interdependent organisms and their surroundings. In the information age, people, activities, codes, components, and systems form the same kinds of interrelationships. Interfaces are the multidimensional border zones through which these relationships are constituted. Interface ecology investigates the dynamic interactions of media, cultures, and disciplines that flow through interfaces. The semiotic encodings of these wide-reaching systems of representation are their interactions' building blocks. Interfaces recombine semiotic codes, forming hybrids.

On the one hand, the intentional sites of intermedia, intercultural and interdisciplinary activities are implicit interfaces. One example is the intercultural performance *Coded Messages: CHAINS*, [Kerne, Kofi and Lang 1996] which juxtaposed traditional *Ewe* drum language with postmodern performance strategies. On the other hand, explicit interfaces, such as those between human and computer, also function as border zones. An example is located in the Internet, in particular in the processes of browsing and searching, in which *CollageMachine* is situated. Through its development and activities, an interface comprises an open set of multidimensional, multileveled relationships between people, components, codes, systems, and their surroundings. It functions as an ecosystem.

3.1. the context of the information age

> ... Visualize the major transitions in early human history (the transitions from hunter-gatherer to agriculturalist, and from agriculturalist to city dweller) not as a linear advance up the ladder of progress but as the crossing of nonlinear critical thresholds (bifurcations). Much as water's solid, liquid, and gas stages may coexist, so each new human phase simply added itself to the other ones, coexisting and interacting with them without leaving them in the past. Moreover, much as a given material may solidify in alternative ways (as ice or snowflake, as crystal or glass), so humanity liquefied and later solidified in different forms.
>
> – Manuel De Landa, *A Thousand Years of Nonlinear History*

We live in the information age. By information, I mean representations of what is going on. Information, or data, refers to signals gathered from sensors, and to results collected from devices. Information can be transmitted and stored. This document is information, as are temperature readings inside and outside my house during my last 12 hours of writing. Information's more rarefied counterpart, knowledge, adds a component of cognition. Knowledge includes models and mechanisms for utilizing information. Knowledge is information digested. Knowledge is based on understanding. It includes decision making frameworks. While information and knowledge date back to the beginning of history, the information age is the period of history in which products and services based on information and knowledge claim principal economic value. As the information age has established itself, digital forms of information, which can be processed by computers, are of prime importance. The information age follows the industrial age, wherein manufacturing – principally in the form of assembly line production, characterized by interchangeable parts and labor – was the primary source of economic value. During the industrial age, imperial powers extracted raw materials from colonies outside of the economic center, that is, outside of Europe, America, and Japan. Transportation and communication infrastructures were built to support this process. Previously separated cultures were brought into contact, albeit in a one-sided manner. European and American commercial centers extended their control of the margins. Cultural anthropology came into existence to investigate the cultural exchange occurring in these by and large economically driven border zones.

Indeed, the above description of the flow of cultures contains an anachronism. Not only did cultural anthropology develop as part of "international economic development", but our very notion of culture as plural, rather than as the single "objective" standard of *high culture* – coevolved with this same process [Williams 1983]. It would be more accurate to say that previously separated ways of life came into contact. While removed ways of life had come into contact in earlier historical contexts, such as the Roman empire, the extent of such contact, both in terms of breadth and depth, crossed a threshold during the nineteenth century. The modern, plural conception of culture[1] – as the tangible manifestations of a way of life, and the associated values, aesthetic sensibilities, and states of consciousness – originated not before, but during the same period. This definition implies knowledge of the existence of distinct ways of life, and thus of a great heterogeneous world of cultures. However, ironically, the contact through which imperialism made "civilization" aware of various cultures, concurrently began a process of reduction of heterogeneity. These were the seeds of multinational capitalism, of the omnipresent hegemony of international financial markets and

[1] My personal take on this subject is influenced by many, including Kroeber and Kluckholn[1952], Williams[1983], and Geertz[1973].

transnational corporations, from the British East India Company to CNN[2]. Thus, even though it has roots from the dawn of the industrial age, *culture*, itself, is an information age concept. It finds fruition, as well as dilution, in the global village of electronic media networks. When everything is connected, distinctness comes only through intention. Respecting the value of and the need for the expression, representation, and communication of heterogeneous cultural voices recurs throughout this work.

As De Landa observes, the form of history is not a linear, monotonic progression. The information age did not replace the industrial mode of production; it only eclipsed its significance. Historical ages overlap. We can identify their passage in terms of the formations that are required to begin an essential transition, the reactants that catalyze this transition, and the threshold phenomena that mark the transition as an essential shift. Thus, while we might correspond the onset of information age to various events, such as the proliferation of the Internet during the 1990's or of the personal computer during the 1980's, the antecedent formation of *culture*, though it overlaps with the industrial age, nonetheless marks the information age's origin.

An artifact is literally, a thing made through the knowledge and practice of human art and workmanship. [Oxford University Press: 1992] As culture is a primary form for representing, storing, transmitting, and producing knowledge of human practices, so artifacts are material forms of culture. They are material representations of a way of life. Artifacts are implements of use and aesthetic

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[2] AKA the CNN division of AOL Time Warner.

expressions that both reflect and create the ways in which people individually and collectively think and act. Artifacts are situated in particular locations and practices.

In the information age, information and knowledge, themselves, form the basis of essential artifacts. Information and knowledge may be stored in forms that humans are unable to access directly, like the electronic charges on a magnetic disk spinning 7200 revolutions per minute. Even the first layer of decoding those charges – the long strings of ones and zeroes – are not interesting to us. What we deal with are *media representations* of information, and the tools (meta-artifacts) which deliver them and enable their production. Media are sensory renderings into perceivable and usable forms. Information and knowledge cannot function as artifacts without being rendered through media. In concrete analog form, this means paintings, books, and films, as constructed with paint brushes, paper, printing presses, film stocks, and editing bays. In the digital realm, the media of information artifacts include images, documents, programs, multimedia, and hypertext, as developed with editors, processors, browsers, and players. In both the analog and/ digital domains, each medium is associated with particular technologies.

While the primary economic and semiotic role of knowledge artifacts is an information age phenomenon, the crystallization of knowledge into artifact forms has occurred throughout history. Michelangelo's frescoes in the Sistine Chapel, Homer's Odyssey, a song sung to bring rain, a dance performed to prepare for battle, and a codified plan for when to plant seeds and tend them in certain ways in relation to climatic signs; these knowledge artifacts are also things made. They are material representations of culture, embodiments of understanding.

As an artifact is an object made by hand or by other artifacts, what is not an artifact is the natural, that is, entities that exist on this earth independently of human beings. These are the province of biological ecology, which examines the dynamics of constellations of organisms in their environment. However, with the dominance of the planet by homo sapiens, and the rise of the information age, information artifacts are profligate and powerful. They are also involved in complex, dynamics of interrelationship, which bear consideration, in order to understand what it means to produce and consume them.

3.2. ecologizing: an initial basis [interlude 1]

3.2.1. cyborg ecosystems

> The cyborg is a hybrid creature, composed of organism and machine... Cyborgs … are made of, first, ourselves and other organic creatures in our unchosen 'high-technological' guise as information systems, texts, and ergonomically controlled laboring, desiring, and reproducing systems. The second essential ingredient in cyborgs is machines in their guise, also, as communications systems, texts, and self-acting, ergonomically designed apparatuses… Modern medicine is also full of cyborgs, of couplings between organism and machine, each conceived as coded devices, in an intimacy and with a power that was not generated in history of sexuality.
>
> – Donna Haraway

Cyborgs are essential information age entities. They are producers and manipulators, renderers and renderings of information artifacts. While they possess or at least suggest agency, when dissembled, their components may require constructed contexts in which to function. These components may also lurk in the dark recesses of contexts, uninvited, without seeming to have been constructed at all.

The emergence of cyborgs reflects human beings convergence with information systems: those systems push and deform all of humanity, in multifarious ways. They enable some of us. They impose on us. Some privileged few of us get to define them, on various levels. Use and be used. Cyborgs effect consciousness, representations of identity; they *are* representations of culture in media, as they also *produce* the same. They impact labor, and leisure. Carry a cell phone. Wear a computer. Network thyself. I am writing on a computer with cable net access in my living room. This means that, on the one hand, I didn’t have to travel to get to work; on the other hand, it means I have no refuge from my work. I cannot go home and leave it behind. I can surf the web on a whim. This addictive over-stimulation imparts costs and benefits. Meanwhile, my friends in Anyako are without electricity and telephones, let alone the Internet. Nonetheless, multinational economics – even the vagaries of the NASDAQ – structure their local economic circumstances. Cyborg combinations are fraught with duality, with multiplicity, exciting and imposing, engaging complex networks of many to many relationships. Cyborgs raise possiblities both of imposing, totalitarian, machinic domination, and of partial, plural, multivocal accommodation.

Haraway offers cyborg as a term which expresses deep conflicts and extreme multivalences in humanity's deeply dependent relationships with technology. Cyborg includes both our fear of the Frankenstein monster, and our inability to live without prosthetics, such as pacemakers, and drugs which join our biochemistry. Haraway cites science fictions deliberately, as fonts of imagination to develop and align with, while identifying technology both as a source of problems and oppression, and as a source of power. One example of this oppression is the role of third world women in the production of microchips. They work extreme hours in cramped, toxic conditions for little money. Then a fast machine can be on my desk. Another is the environmental havoc caused by chemical waste resulting from integrated circuit manufacturing.

Cyborg forms do not universalize our experiences with technology. They do not enact the modernist mirage of technological progress working to make the world a better place. Instead, they converse – that is, they pass messages – in dialogues of *oppositional consciousness*, wherein identity comes from otherness and difference, rather than unity. The oppression and the empowerment, the factory worker and the artist/researcher (such as myself) both need to be considered. For example, Sachs [Sachs 1995], illustrates how a new system for handling “trouble tickets” among NYNEX repair people destroyed productivity. The design of the mainframe computer-based Trouble Ticketing System (TTS) ignored the role of implicit, social interactions in how the job was done. Simply, people had collaborated informally in diagnosing problems. The new system monitored their time too closely, and it gave them no way to get credit for helping each other out. Sachs and her team added structure to the new system which maintains tight controls, but adds enough flexibility so that the necessary collaboration can occur. What is missing from Sachs’ analysis is giving credence to the fundamental tension in that system, and her role as a human computer interaction professional. Sachs does mention that she worked with a design team composed of “eight people from the operating company, four union workers and four first-line managers, all of whom were ‘hands-on’ workers in the process being redesigned.” [Ibid: 38] But while she quotes these people with regards to work practices, she does not mentions their feelings about the underlying goals of TTS, or about the scope of their efforts to fix it. Crucial dimensions of the worker’s perspective – perhaps they also just like to interact with each other informally – are not represented. The possibility of values other than economic ones is rendered as invisible. Giving credence to diverse voices, such as these, is essential to the cyborg oppositional consciousness that Haraway prescribes.

Biological organisms are so fundamentally interdependent, that the perspective of ecology is necessary to understand the life cycles of interacting species. The relationships of cyborg components are similarly enmeshed. Cyborg forms are the fundamental components of information age ecologies. Cyborg components are composed together to form systems. These systems may act as components again, which can again be composed together to form more complex systems. Components may be connected by networks, loosely or tightly coupled, in which they act as nodes. Membership in some networks is tightly controlled; in others, such as the Internet with reference to some dimensions[3], it is quite open. Many of these relationships are created by design; that is, they are explicit. An application program calls a system subroutine. A drug regulates blood pressure. An Internet service provider is contracted. Then there are the unintentional, implicit relationships. What content can my nephew access on the Internet, or for that matter, on television? What perspective do users bring to the software that I write? How am I connected to the people who assembled the integrated circuits and circuit boards of this computer? What forces define which performative and interactive projects I can work on? What is viable commercially? What is research? What is art? How is this very piece of writing situated?

On the playground wall of the information age, it is written: "Cyborgs rule." This is almost a tautology. Cyborgs are the prototypical entities of the information age, they are the integrated systems of human and machine that produce, manipulate, and transform information artifacts. The energy flows among cyborgs are complex, subtle, multilayered; these flows define the terrains both of cyberspace and of the real world. The political and the economic, the social and the cultural, science and

[3] Access to the Internet is open to people of certain economic means, especially in well-wired parts of the world such as the United States, Europe, and Japan. So it is open to some large

art, content and technology, freedom and labor – all of these flow in cyborg assemblages that function as ecosystems. One part of inquiry into cyborg ecosystems is to come to terms with multivocality, in general, and the positioning of one's own voice as interlocutor, ethnographer, developer, designer, author, scientist. Another is to consider the consistent DNA coding of media, cultures, and disciplines, that is signs, and the processes through which they evolve. With that framework in place, we can explore the dynamic processes of hybridization afforded by exchange. *Interfaces* are the border zones through which cyborg components exchange coded messages. In order to proceed, I will begin by developing the axiom of *equal value*, which serves as a starting point in interface ecology. Equal value gives multivocality operational form in the praxis of the ecologizer.

3.2.2. equal value

> Composition had consisted of a central idea, to which everything else was an accompaniment and separate but was not an end in itself, and Cezanne conceived that in composition one thing was as important as another thing... One human being is as important as another human being … You might say that the landscape has the same values, a blade of grass has the same value as a tree... I began to play with words then. I was a little obsessed with words of equal value.
>
> – Gertrude Stein

Gertrude Stein posited *equal value* – a way of writing in which all words and aspects of what is represented are treated democratically: they are given the same rights and responsibilities, the same weights; each carries the same value. She referred to value first in a painterly way; that is, in this context, value literally means how light or dark something is, the magnitude of its brightness. Stein's application of equal value was multi-scale. On a micro level, she composed words with equal value through her

---

set of people and closed to some larger set of "others".

choices of details. She also gave structural form to this micro-level equal valuation through syntactic style. These compositional practices are illustrated by this passage from *Ida*: “Anybody can go away, anybody can take walks and anybody can meet somebody new. Anybody can like to say how do you do to somebody they never saw before…”[Stein 1941: 96] On a mid-level scale, Stein represented the equality of human beings through her choices of characters, and mode of character development. Her protagonists are not notable for their status or special achievements. There are no climaxes. For example, when Ida is a child, her parents leave and she experiences a succession of guardians and home environments. These events receive perhaps less attention than the succession of her dogs.

Because interfaces play such an important role in the information age, the investigation of what is going on in them warrants attention. Like Stein’s writing and Cézanne’s painting, the exploration of interfaces calls for a multi-scale equal value approach. The exchanges hosted by interfaces span many different levels; they encompass multifarious aspects of life; many different creative (cultural), technological, political, and economic energies are fluxing. Separate disciplines have independently investigated these fluxes. This approach is prone to missing the big picture. The constellation of the interface demands an equal value combination of disciplines. Like Stein with words, I, myself, am obsessed with media, cultures, and disciplines of equal value.

I want to mark the structural jump in discourse here. I am using an artist’s approach to the composition of text as a precept for the study of interfaces in general, among which human computer interfaces are a subset. This jump is accentuated by strictures on the investigation of interfaces which have become common practices because this domain has heretofore been dominated by science and economics. An equal value framework will not discount the contributions of those disciplines; it will rather shift their context by combining them with others. Alternatives to the top-down deduction of the scientific method and nearsighted profit and loss projections are thus granted equal footing with them. The form of this mix will not be static. The constituent components and their relative strengths must be tuned appropriately, on demand, according to context. Ethnography – anthropology's writing of cultural accounts – is one such constituent.

3.2.3. voice and the role of the ecologizer

3.2.3.1. ethnography: interpretation in thick description

> The concept of culture... is essentially a semiotic one... man is an animal suspended in webs of significance he himself has spun. I take culture to be those webs, and the analysis of it to be therefore not an experimental science in search of law but an interpretive one, in search of meaning.
>
> – Clifford Geertz, *The Interpretation of Cultures* [1973: 5]

Ethnography represents culture as text. It forms anthropological knowledge. "Doing ethnography" begins with examining cultural forms, such as artifacts, events, rituals, customs, work practices, and symbol systems. This examination includes discovering the relevant background which makes the occurrence of these forms comprehensible. From examination, the ethnographer proceeds to analyze and render these cultural forms. According to Geertz, doing ethnography is an elaborate venture in "thick description". [Ibid: 6] The explication of cultural forms requires referencing their context, including the social, historical, political, psychological, technological, and economic situations both of the ethnographer and her/his subject. Creating thick description means producing “piled-up structures of inference and implication”. Codes of signification must be sorted out. Figures are rendered on grounds. Is a *CollageMachine* user at work, in a café, in the foyer of a public building, in a museum exhibition, at home in the living room, or in the bedroom? How old is s/he? Is s/he accomplishing a task or seeking entertainment? Or is some mixture of these goals and values in play? All of these influence how s/he will perceive the interactive artifact. The same could be said with regard to how *Ewe* drumming / dancing is perceived when it is performed in Anyako in the town square, or at the shrine of *Yeve*, or if it is performed in New York City at Lincoln Center or Washington Square Church. The same rhythms may be played, the same choreography executed, and yet the meaning will change. The interpretation will change. The function will change. Ethnography accounts for this. A basis of personal and institutional relationships provides the data of observations and interviews. Rendering means developing a multiplicity of complex conceptual structures, such as linkages, maps, diagrams, genealogies, lexicons, and other texts, images, and aural forms.

I mentioned already that the contexts both of the author and of the subject come into play. This is what Geertz refers to when he identifies the interpretive nature of the ethnographer’s endeavor. There are no absolutes, no objective perspectives. Postmodern ethnography has focused on this fulcrum in the ethnographic relation. Clifford points out that ethnography creates “an inscription of communicative subjects in relations of power.” [Clifford 1986: 15] This contrasts with Geertz’s, “The ethnographer inscribes social discourse; he writes it down.” [Geertz 1973: 19] The nature of engaging in interpretation is brought into focus. Any construction of "the other" is always just as much a construction of the self. In the same vein, doing ethnography is a creative practice, fictive, more full of poetics than of objective facts. Thus, Clifford identifies ethnographies as literature. In doing so, he takes offense with the taboo against emotional, literary, and poetic voice in scientific texts. Crapanzano [Crapanzano 1986] critiques the rhetorical devices that ethnographic accounts typically utilize to establish definitive, objective voice.

3.2.3.2. the *vocal representation limit* principle => *equivocality*

> Situated knowledges require that the object of knowledge be pictured as an actor and agent, not a screen or a ground or a resource, never finally as slave to the… authorship of 'objective" knowledge.
>
> – Donna Haraway, "Situated Knowledges" [1991: 198]

Crapanzano's critique results in a call to make ethnography more a matter of dialogue, than of one-way interpretation of "the other". One way of accomplishing this is through collaboration with insiders in the construction of accounts. This approach is hardly satisfying when it is not conducted on truly equal terms. A contemporary response is the education of members of various cultural groups as anthropologists, resulting in *emic* accounts. J.H. Kwabena Nketia's, *The Music of Africa*, a detailed and comprehensive survey which carries authoritative status among ethnomusicological texts about that continent, is an example. An ironic feedback side effect emerges: more heterogeneous ethnographers come with more homogeneous subjects. The incorporation of individuals from diverse locales into mainstream institutions indicates that the locales, themselves, are more interconnected, and thus less diverse. As institutional interfaces function both as barriers and as openings, they may simultaneously contribute to and reduce heterogeneous representation. While there are exceptional individuals, such as C.K. Lãdzekpo of U.C. Berkeley who do both, in many cases, more value is placed on education in the universities of the center, than on local cultural traditions.[4] However problematic, the development of ethnographic discourses which render multiple voices, perhaps including various constituents of a culture, as well as outsiders, is desirable.

Ethnographers have identified the need for the author's voice to be rendered explicitly, along with "subjects", in the process of interpretation. From this principle, comes the need, for example, to express ideas from the first person perspective of *I*. I expect some scientist readers of this text are already irritated with my practice of this principle. This is not caprice. With her/his perspective hidden, the author dominates through a voice of objective authority.

Haraway identifies the multivocality of constituents, and calls for articulations of difference within cyborg discourse. Stein said that one human being is as important as another human being. These perspectives are consistent. There is a need to seek diverse representation. How do voices and their cultural contexts get represented? More work needs to be done to develop processes both for eliciting such representation, and for forming it. For the former, consensus process is suggested; for the latter, hypertext (See Section 3.3.3.5). Thus, any rendering must be seen as partial, imperfect, subject to question, and full of explicit and hidden value judgments. This is the *vocal representation limit principal*.

[4] Certainly, over the last 3 generations, my own family has taken this path. So much so, that, by and large, I feel like I lack in-depth cultural traditions. (I believe that I must comment on

Consensus process is a way for members of a group to work together to make decisions. It places great emphasis on the voices of individuals; it works to synthesize them to form proposals that become the basis of agreements. There is no majority rule. Decisions are not completed until all agree. When there is no basis for consensus, individuals or subgroups proceed autonomously. From my work with consensus , as an activist in the anti-nuclear movement, I know that it is wonderful when the members of a group share certain core values, and awful in other cases. With the caveat that a basis of core values is a prerequisite, I suggest the application of equal value to the representation of voice in ethnographic accounts. *Equivocality* means that all voices, including diverse constituents, and an author or authors, should be represented equally. Consensus process has been designed towards achieving equivocality.[5] A role for the ecologizer in interface ecosystems is to seek equivocal representation.

3.2.4. notes on nomenclature

To *ecologize* is to "do interface ecology". I have created this signifier in order to emphasize that engaging in interface ecology is an active process. From this verb form, I derive the noun, *ecologizer*, that is, one who does it, who ecologizes; one who actively participates. This framing contrasts with the more obvious *ecologist*, which would seem to connote a narrower process of scientific study.

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myself here, in this way, while commenting on "others", in order to be true to the principles I am discussing in this paragraph.)

[5] Difference may arise in groups with regard to familiarity and identification with consensus. This can result in a sense of exclusion, and thus in hierarchy.

Also, I use the terms interface ecology and information age ecology more or less interchangeably. The latter term serves to position the sense of the concept in its historical period (that is, now). The former is a small restatement of interface ecosystem. This chapter establishes what I mean by interface ecosystem. By demonstrating that interface ecosystem is the fundamental unit of information age ecology, I will establish the equivalence of "interface" and "information age" ecology.

3.2.5. bootstrapping

To be internally consistent, I am developing this definition of interface ecology in an ecological manner, that is, in its own terms, and through its own processes. This explication is limited by its linear development. While I am engaging in exegesis, I am unable to do this all at once. So I am forced to use terms and engage in processes that I have not yet defined, and to define them somewhat in terms of each other. Therefore, at this stage I present equal value as an axiom and a cultural value, that is, as a principle which must be accepted as given. Later, I will show that equal value and equivocality are instances of the dynamic structure called *meshwork*, and that as such they exhibit certain desirable characteristics.

The process of initially "bringing up" a system defined in terms of itself is called bootstrapping. The history of language translators in computer science includes extensive examples of bootstrapping. Most programs are written in "higher level languages" which must be translated into a processor's native "machine language" in order to run[6]. Translators that translate one line of a program at a time, interactively, are *interpreters* and those that translate an entire program all at once are *compilers*. The venerable artificial intelligence language, LISP, is notable for its consistency of form: support for the datatypes of programs written in the language, linked lists, is built-in. Further, LISP includes an *eval* operation, which enables programs to directly build and execute other programs. The bootstrapping of LISP began with the development of a simple interpreter, written in machine language (the read-eval-print loop). This interpreter was extended, with code in LISP. Then, a compiler was written in LISP. This compiler could be used both to compile itself, and to compile a new version of the interpreter, written in LISP from the ground up. Once this bootstrapping had been achieved[7], new translators, extending functionality and improving efficiency, could be written entirely in LISP.

Interface ecology is not a formal system; it doesn't execute sequentially; and of course, it is not based only on logic. It includes both well-formed and fuzzy components. Postulating equal value, initially, bootstraps the process that will be used to develop concepts such as semiotic code, significant behavior, structural dynamics, ecology, and interface. This bootstrapping is nontrivial. I would not mention this, except that I have noticed that people tend to resist it. One reviewer of an early interface ecology paper said, "The paper itself is indeed a collage, without a strong structure or a discourse to help the reader step by step. The variety of sources for the ideas is astonishing; the relations are hardly ever made clear…

[6] Machine languages are specific to particular processors. Higher level languages strive to be processor-independent.
[7] except when porting to a different processor or operating system, that is, to a different platform.

Definitely reject." The need to draw from a wide range of the sources – and their associated ways of thinking – is a direct result of Newell and Simon's inclusion of "what goes on around the computer" in computer science. To avoid this interdisciplinary mélange is to hide one's head in the sand. This is the nature of interface phenomena. Furthermore, collage *is* a strong structure; it is just not a deductive one. In a realistic inquiry, the means for making the relationships clear cannot be limited to deduction, nor can the vocabulary and approach be limited to that of any single preexisting medium, culture, or discipline. This work is challenging. Crossing borders requires exposing oneself; it requires repeated forays, into, "I don't know." For individuals who are accustomed to being experts, this may be intimidating. It requires letting go of the safe control of blanket expertise; it requires a certain open-mindedness. The benefit to be reaped from the interface ecosystem nexus is understanding the dynamics of these complex, critical power spots. From the shortcomings of belief in the primacy of any one discipline, comes discovery of the benefits of their equal value combination.

3.2.6. recursion analysis

Interface ecology is full of self-reference. Subjects, objects, and methods cross over, exchanging roles. The blending of theory and practice creates a tangled referential hierarchy – a strange loop. Languages are used to describe themselves, and their processes of derivation and transformation, even as they are being derived and transformed. *Recursive* is what computer scientists call a function that, in the process of computing its results, calls itself again, passing the intermediate result as an argument. A recursive data structure is one that repeats inside of itself. Such self-referential structural repetition also called *nesting*. The natural, political, social, and economic worlds are full of recursion. The growth of sea shell structures through spiraling accretion is an example. Recursion analysis can untangle and explain a wide range of phenomena in cyborg ecosystems.

Interface ecology is replete with multidimensional recursions: even as a function is executing a recursive call, it may also pass itself to itself as an argument, and modify

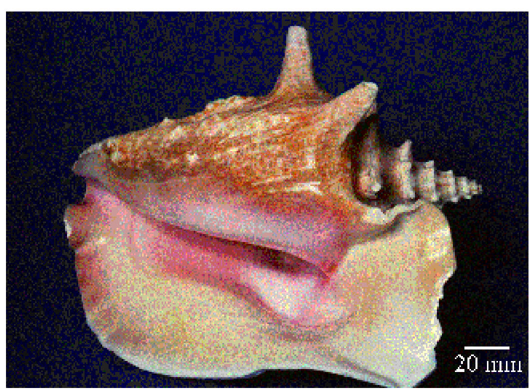

Figure 3.1 Nesting of turns in the stem of a conch shell. This structure originated recursively. Photo courtesy of Roberto Ballarini and Arthur Heuer of Case Western Reserve.

itself in the process. This kind of intense, multileveled feedback is characteristic of ecologies. Different levels of real world chemical reactions proceed in parallel: geologically and meteorologically, defining environments; biochemically, defining day to day metabolic exchanges of energy between organisms; and genetically, through the formation and exchange of DNA. Feedback occurs between, as well as within levels. With the bootstrapping of interface ecology, a multi-branching self-referential chain begins.

3.3. dynamic systems of representation

> ...Human culture and society (considered as dynamical systems) are no different from the self-organized processes that inhabit the atmosphere and hydrosphere (wind circuits, hurricanes), or, for that matter, no different from lavas and magmas, which as self-assembled conveyor belts drive plate tectonics and over millennia have created all the geological features that have influenced human history. From the point of view of energetic and catalytic flows, human societies are very much like lava flows; and human-made structures (mineralized cities and institutions) are very much like mountains and rocks: accumulations of materials hardened and shaped by historical processes.
>
> – Manuel De Landa, *A Thousand Years of Nonlinear History* [1997: 55]

Systems of representation and their relationships are based on common building blocks and processes which store, transport, and transform meaning. The study of the way language conveys meaning in society is the province of semiotics. Geertz prescribed the need for semiotic interpretation as part of ethnographic analysis (See Section 3.3.2.). The fundamental representational unit in a semiotic system is known as a *sign*. A system of representation – of signs – forms a *semiotic code*. I will call the actions that people engage in which form and act upon signs – that is, which create and transform meanings – *significant behaviors*.

As we can apply recursion analysis to cyborg ecosystems, including their semiotic components, we can again draw from computer science, by utilizing data structures and object-oriented programming constructs in semiotic analysis. The semiotic analysis of cyborg ecosystems develops generalized data structure templates, which are filled in under particular circumstances, to form instances. Signs correspond to objects. As with objects, their composition may include nested signs. Significant behaviors correspond to methods. They may take, or be passed, signs as arguments. They may return new/altered signs and significant behaviors as results.

Two enhancements to object-oriented design are required to handle systems of representation. First, the validity of any semiotic model is subject to the vocal representation limit principle. The model will represent the interests of its builders as much subjectively as objectively.

Second, nothing is static in these systems. That is, the templates themselves are constantly evolving; they are both self-modifying and subject to external conditions which can alter their definitions at any time. More specifically, a significant behavior, through its operation, may alter the definition of its own data structure, the definition of signs that it operates on, and the definition of other significant behaviors. This is a fluid structure, not a rigid one. In summary, both the data structure definitions and the values of particular instances may be modified.

3.3.1. signs (objects)

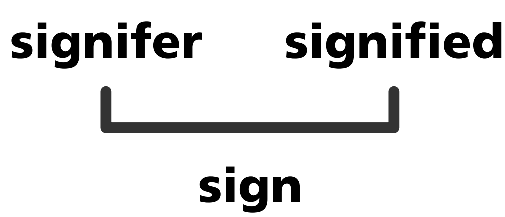

Figure 3.2 First-order sign system template.

3.1.1.1. signs – Saussure

Signs are the fundamental atomic units which makeup semiotic codes. Within the sign, Saussure delimited two functional units: the signifier and the signified. [Saussure 1966: 67] They are similar to the name of a variable, and its value. The signifier is the label associated with sign, its handle or name. Saussure defined the signifier in terms of spoken language, where it is the sequence of phonemes. The signified, also known as the referent, is that concept which the signifier stands for. So, for example, the sound and text of the word advertisements, that is, &d'v3:tIzm@nts and "advertisements", form the signifier whose signified is the

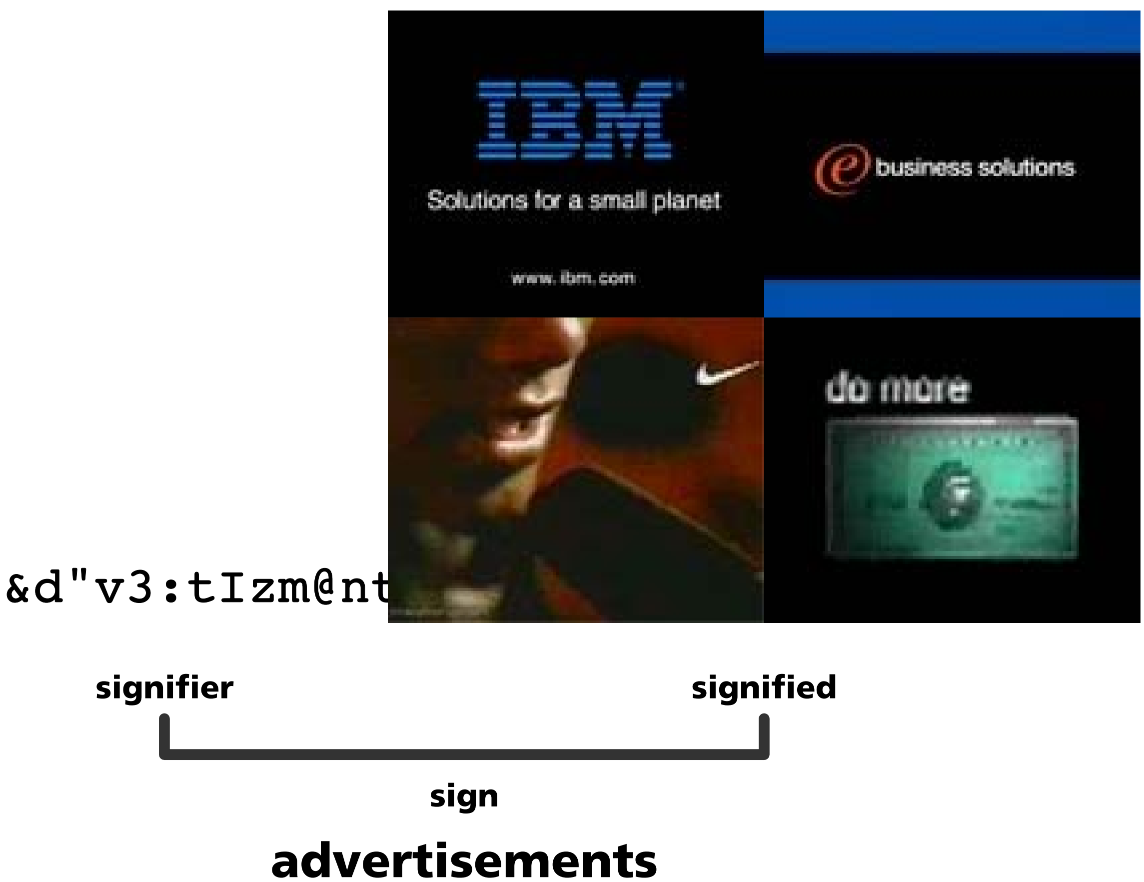

Figure 3.3 First-order sign system - advertisements instance.

concept of advertisement (plural), that is, a set of media representations, each of which functions to promote a product. The conjunction of signifier and signified together is the sign.

Figure 3.4 First-order Nike shoe sign system. The *Swoosh* is the signifier; the actual shoe is the signified.

Barthes extended the work of Saussure. He developed a series of interpretations of signs in context, which are based, first, on a generalization of signifier. This opened the scope of semiotic analysis, for our adaption and application. For written language, the signifier/label logically refers also to the sequence of characters. Further, signifiers can also be pictographs, like the image of Nike's logo (the *Swoosh*), sound sequences, like the crescendo, fast strumming and final power chord which indicate the end of a rock-n-roll concert, or moving image devices, like dim lighting coupled with odd camera angles in a movie which indicate uneasiness, that something is hidden or amiss.

3.3.1.1. political economy: the commodity form, use and exchange value

> Value ... transforms every product into a social hieroglyphic... The ... scientific discovery that the products of labor, in so far as they are values, are merely the material expressions of the human labor expended to produce them, marks an epoch in the history of mankind's development…
>
> – Karl Marx, *Capital*

In order to understand Barthes' next structural extension of sign, it is necessary to look at Marx. Marx was a pioneer in the development of structural interdisciplinary amalgams. He found that power relationships in society are based on economics, so he called his study *political economy*. Further, the *social relations of production* reflect the *mode of production*; currently, that is capitalism. The open set of social relations of a society is more or less equivalent to its culture. Marx's basis for validating the conjunction of cultural, political, and economic matters hinges on two key concepts: the commodity form, and exchange value.

Marx writes, "The commodity is, first of all ... a thing which through its qualities satisfies human needs of whatever kind. The nature of these needs ... makes no difference. Nor does it matter here how the thing satisfies man's need…" [Marx 1867: 125] Marx defines two kinds of economic value. *Use value* corresponds to the utility of a commodity to one who consumes it, that is, to its satisfaction of that person's needs. If you are suffering from malaria, a treatment is worth a lot to you. Under capitalism, a second kind of value, that is, exchange value, represents the value a commodity is worth on the market. In New York City, perhaps that treatment is in large supply, easy to obtain, even passed out for free by the government under some circumstances. Perhaps in a remote town in Mali, it's hard to get, and its exchange value might be considerably higher, even while there is much less capital in circulation there. If you are sick and need the treatment, its use value would be invariant across these locations, while its exchange value might vary extremely.

Exchange value is the basis of the commodity form and the social relations of production. Like goods, labor is exchanged through the market mechanism, so it is also a commodity. Marx says that social relations have been transformed by markets through the commodity form, and are structured on this basis. Instead of working directly for each other, we work for money. So the relationships around our labor are not direct human ones, but indirect economic ones. This is called *alienation*. [Ibid: 203]

Acts of labor – that is, what one works on, and how, day in and day out – as well as how the fruits of labor are distributed, are essential to cultural identity. So labor and culture are inextricably linked. Furthermore, *colere*, the root of the word culture, was associated with agricultural production. In pre-capitalist times, that meant subsistence. Thus, *culture* connotes sustenance, which includes work essential for survival. The commodity form and the process of exchange translate experiences of work from cultural to economic value. Analysis of the exchange of commodities crosses borders. The translation from one system of representation to another requires a conjunction of disciplines.

Our production of meanings, like our labor, is subject to the process of exchange, and thus of alienation. In the information age, the exchange of sign values [Baudrillard 1981: 147] takes a primary role. That is, the exchange of signs is more significant than the exchange of material goods. Sign value assigns status to ideas, practices, and materials. The complete set of sign values in operation constitutes a code. The code maps artifacts to levels of utility and leisure. A human being is defined in terms of her/his sense of satisfaction which is consummated through the consumption of signs.

3.1.1.2. myth and the context of the sign

Barthes made further extensions to Saussure's framework. Structurally, these extensions can be seen as recursive formations of the sign concept. [Barthes 1972: 114-159] Barthes drew a second, structurally identical, level of signification over the base sign system, through recursive application of the sign concept to its signifier

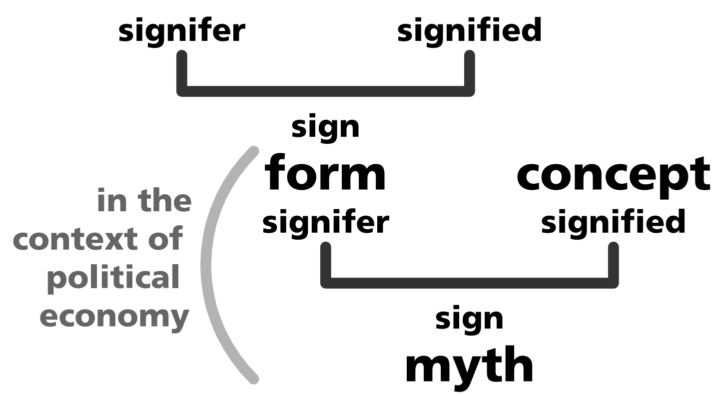

Figure 3.5 Myth, a second-order sign system template.

slot (See Figure 3.5). The context of this recursion is consideration of political economy. Marx had implied the project of decoding the social hieroglyphs of products. In the 2nd order application, the 1st order sign is taken as the signifier, which Barthes calls *form*. That is, the composite of the first order signifier and signified of forms an identifier in the second order sign. The 2nd order signified, which Barthes calls *concept*, is a nested instance of the sign, which is evaluated in the context of political economy.

Marx himself had recognized the hidden level through which political economy contributes to the formation of meanings:

> The forms which stamp products as commodities ... already possess the fixed quality of natural forms of social life before man seeks to give an account ... of their content and meaning... This finished form of the world of commodities – the money form … conceals ... social relations between the individual workers, by making those relations appear as relations between material objects... The formulas [of value] ... appear ... to be ... a self-evident and nature-imposed necessity...

Following Marx's cue, Barthes observed the extent to which meanings which seem normal and everyday – those which are taken for granted as obvious – are in fact based upon the hidden operation of political economy. He called this mechanism *myth* because it functions to frame cultural constructions as objective reality. A myth is a meaning, whose truth seems natural, but is actually the result of complex semiological structure. Myth is constructed through 2^{nd} order semiotic systems, in which it is the resulting, overall composite sign component. This myth wraps together the original amalgam in the implicit, normal context in which it operates in order to generate further meaning. Barthes" myth template is one of many possible nested sign system structures.

The semiological framework of myth is readily applied to notions of universal empowerment that technologists and marketing people often associate with technology. The context for this particular semiotic analysis is the Internet. Signs play a key role in shaping the public's perception of the Internet, of what it means to people. This in turn shapes how people use the net, and how they invest in it. This is the context in which CollageMachine was formed and functions.

Since the mid nineties, IBM has conducted ad campaigns that sought first of all to convince people that the Internet was useful for commerce, and then, especially as this has become apparent, that corporations should buy IBM Internet products and services in order to accomplish their e-commerce goals. One such ad, ironically

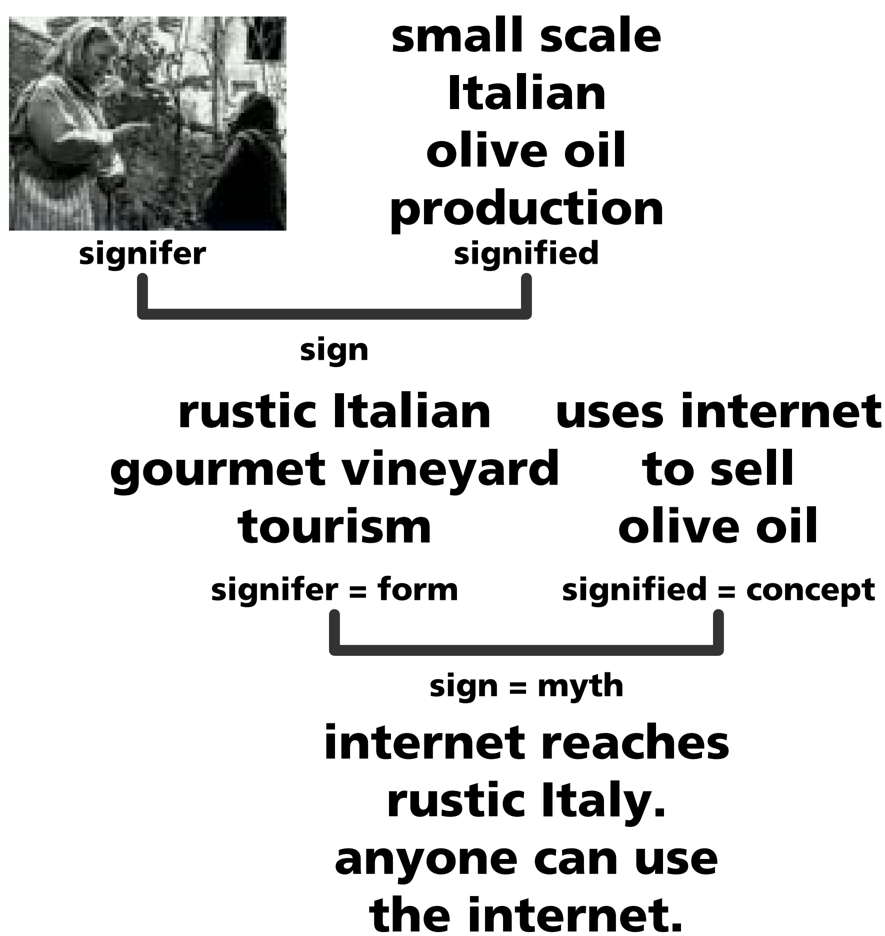

Figure 3.6 2nd order sign system diagram for IBM's "Culture Shock", in the *Solutions for a Small Planet* series.

American Woman:	We're from Ohio.
Italian Woman:	Ohio… We sell in Ohio… and California, … Argentina… [hands over a business card]
American Woman:	They're on the Internet. How can they afford it?

Initially – in the first order signification system – the image straightforwardly depicts a rustic scene. Then, the "shock" – that the Internet is used here for e-commerce – is exposed. In the second order system, the form is American tourism in the rustic vineyard, the signified concept is this shock, that the Internet is here. Together, they produce several aspects of the myth: that Internet access is available in rustic Italy, and that the woman is at ease dealing with her e-commerce system. This is diagrammed in Figure 3.6.

"Culture Shock" is one of several episodes in the *Solutions for a Small Planet* series, produced for IBM by the ad agency Ogilvy and Mather. Others include "Grow any business," which features farmers in a remote area of America's heartland, "Middle of Nowhere," in which a business executive realizes that connectivity can allow him to locate his business out in the desert, away from cities and high rents, and a piece with chanting Tibetan monks. The series slogan references Francis Moore-Lappe's popular book of the seventies, *Diet for a Small Planet*, which offered vegetarianism as an ecologically responsible solution to inequities in world food distribution. Like logos, slogans are ultimate forms of refined signifiers which companies and their ad agencies produce as part of *identity packages*. A third level of signification, which can be found in each episode, positions IBM with regard to the Internet and these remote places. That level is the same for each ad. However, through examining the series of episodes as a whole, a fourth level emerges.

In the new third order system, the ensemble of scenarios, including remote locations, diverse people, and the omnipresent Internet, are the signifiers. The people and locales form a set of global village icons, signifying a blended "anyone",

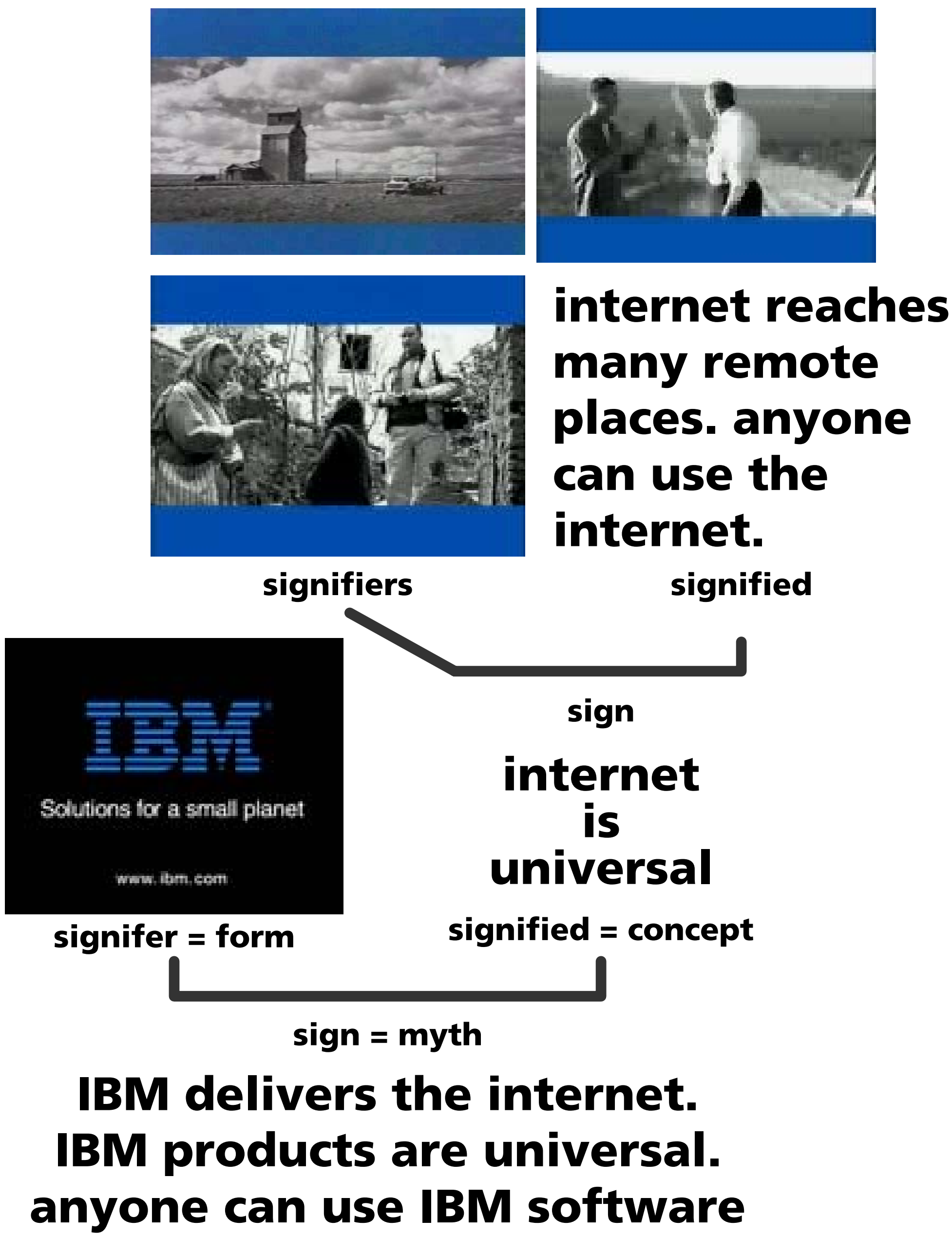

Figure 3.7 3rd and 4th order sign system diagram for IBM's *Solutions for a Small Planet* series.

who is part of “a small planet”. The signified concept is that Internet and e-commerce reach everywhere, and are easy for everyone to use. Conjoined in the

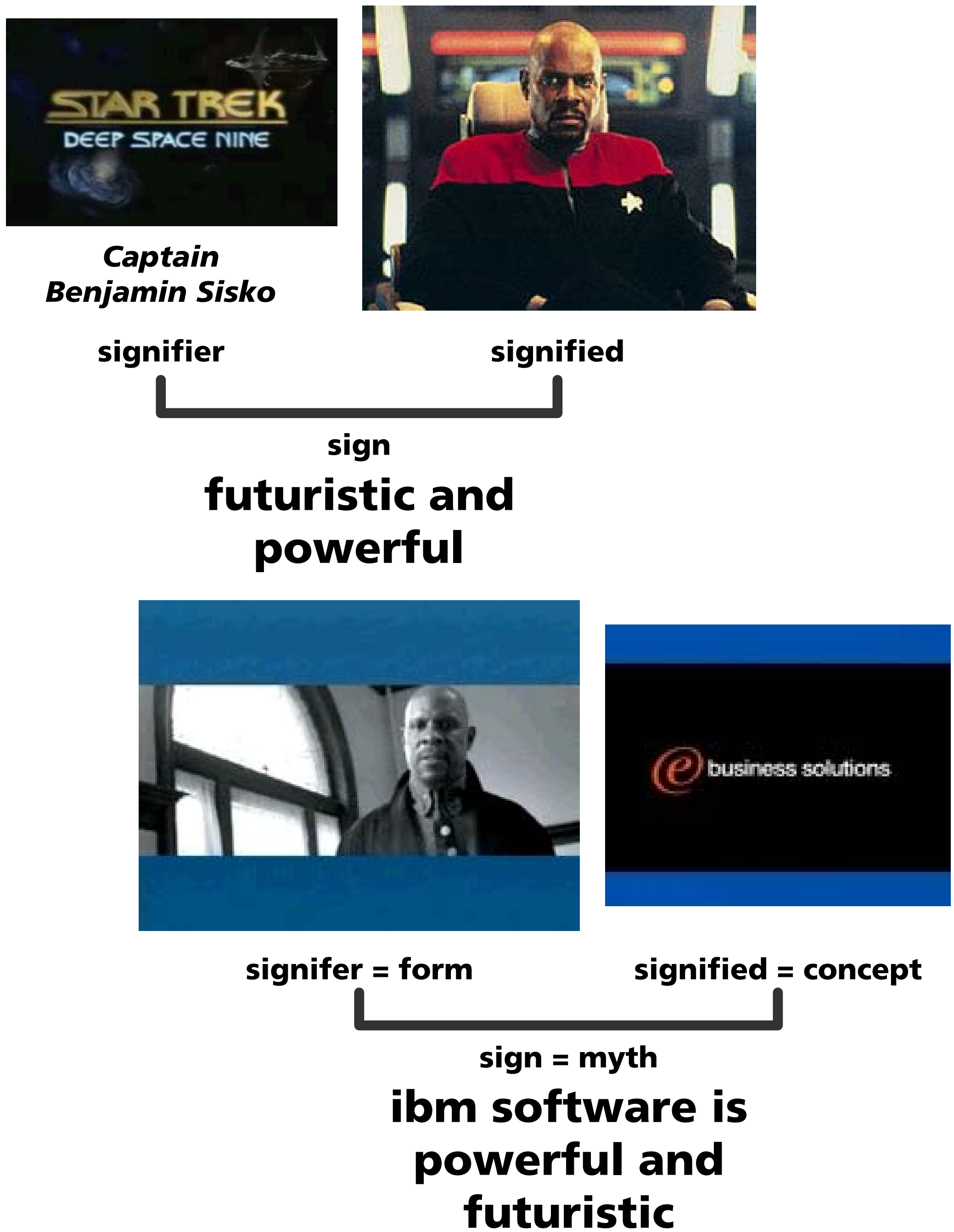

Figure 3.8 Semiotic diagram of IBM’s “It’s a different kind of world, you need a different kind of software” campaign.

This semiotic construction manipulates the meaning of universalism, and suggests that its conclusions are natural and all-encompassing. The implication is that what is good for businesses, large and small, is equally good for everyone. Because the monks, the wrinkled old Italian olive oil farmer, the American farmers, and the business executive were all framed with the same structure of signs, they seem to be equals. Part of the myth is that all are equally represented in the global village and that all have the same economic opportunities on the Net.

As the IBM/Ogilvy campaign progressed, the slogan was changed to, simply, "E-business software." By keeping the rest of the framework the same, a residue of the sign of universal good for a "small planet" was carried through and semiotically bound to the new, business-oriented slogan for viewers who watched the series. Eventually, the nature of the episodes also changed to focus on business scenarios. During the year 2000, actor Avery Brooks – who previously played the captain of a Star Trek series – is featured. A new chain of signification is produced; this time, a brave captain from a futuristic scenario is mapped onto the IBM product lines. (See Figure 3.8.)

Further, the captain's monologue describes a series of "epiphanies": from "the day you realize that babies aren't delivered by storks… the day you realize that men and women are not the same…" to "the day you realize that your website is your business and your software can't handle the traffic". Again, the message is that the experience of the web is universal. Success in the medium – in the form of IBM e-business software, the 2nd order myth/sign – is the signifier in a 3rd order system (not diagrammed). It is conjoined with a series of signifieds: human procreation and hetero-sexual experience, conjoined with the power of a Star Trek captain. IBM's myth making continues.

Sun Microsystems has conducted similar, if less sophisticated campaigns of semiotic myth making. Sun's corporate identity, itself, associates the signifier of the sustaining natural power of the sun with their computer products. In a keynote speech heard by tens of thousands at the 1997 JavaOne Conference, James Gosling, said, "what we have been trying to do is sort of empower people so that people can build their own components." [PC Week: 1997] Again, the myth is that "people" are empowered by Sun's offerings. A related press release states their ideology more directly: "As the world becomes a single, networked, free-market economy, our technologies must allow companies to innovate and compete freely in an open-systems environment." [Sun Microsystems: 1997] The definition of open system is a contested sign. The freedom signified by Sun and IBM is the freedom of corporations to compete. This freedom is represented as universal empowerment. The semiotic construction of these advertisements hides the prevailing multivocal environment of alienation. The Internet is not experienced universally. Various groups of people around the world hold significantly different positions regarding and stakes in the development of information networks. Representations of these conflicting positions are generally omitted from sign system representations.

Sign value was the basis of the recent rise of Internet stocks without regard to definite economic returns. The subsequent fall[8] was likewise based on sign values:

[8] For example, the stock price of Internet agency Razorfish fell from $57 to $16 during two months in the first part of 2000. Their earnings and financial outlook did not change

while some stocks fell because companies' fundamentals were weak, others fell in spite of solid earnings reports. On "the street", sign values shifted: Internet stocks were no longer hot, but overvalued; time to sell.

Through advertising and through Wall Street, the operations of sign values are essential attributes of the Internet context in which I have produced *CollageMachine*. The forces of production push *CollageMachine* to function as an e-business solution. As there are always more ideas about what features to build, than resources with which to build them; even though aesthetic/creative/compositional ideas forged *CollageMachine*'s inception, utilitarian goals drive its on-going development. And, of course, the Java language of which Gosling speaks is the primary language in which *CollageMachine* is written. Indeed, for better or worse,[9] I am one of those who was "empowered to build components". The relationship is simple: I must produce sign values in order to survive, and so I do. The Dadaists, operating more directly in the sphere of "art", did the same. While confronting and challenging the system on the one hand, they produced valuable works through their manipulation of signs.

I began this chapter by identifying interfaces as the border zones where systems of representation meet. Now, I have developed the composition of these systems of representation, as semiotic codes, whose constituent elements are signs. And I have situated myself, and my work, as an Internet project, in the midst of these sign value

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appreciably during this same period of time. [quicken.com http://www.quicken.com/investments/charts/?symbol=RAZF]

[9] Sometimes, I wish I had ignored the Java rhetoric of portable software, and just created a Windows application. Currently, the native Windows API is more powerful, while the promised portability of Java applets (as described in Section 2.x), is inadequately delivered.

interactions. The interface zone creates relationships between the systems of representation, which manifest as relationships between their constituent signs. Signs are transmuted, exchanged, and combined through this juxtaposition. As we saw in Section 2.2, novel combinations promote emergence. Sign values are the fundamental energy units, which are transported through interface's metabolic pathways. This concept will get developed in more detail in Section 3.4, as the operation of the interface ecosystem, following more detailed investigation of the ecosystem and interface concepts. But first, we will benefit from further building blocks, beginning with an examination of the sociocultural processes which animate semiotic codes.

3.3.2. significant behaviors (methods)

Sign systems don't spring into existence instantaneously and simply manipulate people like puppeteers through their codes. Nor does the exchange of commodities pull these strings directly. A dialectic is in operation. Semiotic codes evolve through the shifting dynamics of socio-cultural, technological, political, and economic processes, just as they structure and shape those processes. Because of their role in the formation and invocation of signs, I call the activities in which people are engaged that manipulate semiotic codes, *significant behaviors*. In this object-oriented semiotic framework, they are methods –operators that take signs as inputs and result in semiotic code elements, as outputs. They are also mutually self-modifying, that is, their structures, as well as their instances, evolve dynamically. Significant behaviors structure life. They are more or less repeated behaviors (on the scale of society), which play a key role in making meanings.

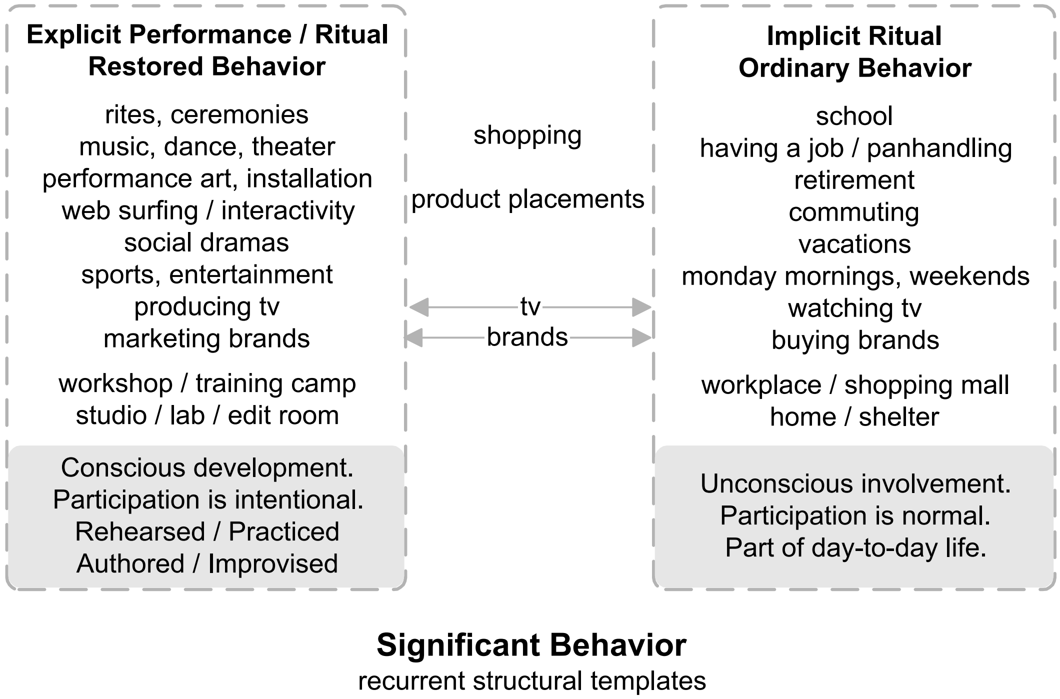

Figure 3.9 Significant behavior consists of restored behavior and ordinary behavior.

3.3.2.1. restored behavior

> Restored behavior is living behavior [that] can be rearranged or reconstructed; stored, transmitted, manipulated, transformed. The performers get in touch with, recover, remember, or even invent the strips of behavior and then rebehave ... them... Restored behavior is symbolic and reflexive: not empty but loaded behavior multivocally broadcasting significances...
>
> – Richard Schechner, *Between Theater and Anthropology* [1985: 35-36]

Significant behavior is an extension and a superset of what Schechner calls *restored behavior*. Restored behavior is the primary constituent of the broad range of activities known as performance, which includes theater, ritual, and sports. Two characteristics distinguish restored behavior. The first, and more obvious, is that is repeated. The second, and more subtle, is that is worked on deliberately, with intent. Restored behaviors are developed by performers, directors, authors, dramaturges, composers, shamans, and/or coaches. Through their repetition, these repeated activities develop resonance as forms of culture. They are a primary means for developing, and form for embodying, meanings, that is, signs. They create and reinforce combinations of signifiers and signifieds, as they also are influenced by and constructed from already prevailing signs. Restored behaviors are developed through processes such as work outs, rehearsals and editing sessions, as well as actual performances. The semiotic codes they develop can exist separately beyond the individuals who perform them.

3.3.2.2. ordinary behavior

As restored behaviors are developed sequences of material which comprise performance, so *ordinary behaviors* are routine activities which, taken together, comprise a significant portion of life in the information age. What they have in common is that instances of a template form are repeated, and that through these processes, semiotic codes are developed, transported, and transformed in the context of the life of an individual, and collectively, of society. The difference is that, by and large, ordinary behaviors are not consciously practiced, worked on, and developed, the way that restored behaviors are. No one with a job rehearses catching the subway to go to work in the morning. No homeless person rehearses standing on line at a soup kitchen to get lunch. Nonetheless, many essential behaviors are routinized. It is not a surprise that, in general, these behaviors are part of production and consumption; that is, they hinge on economic exchange. As such, they are the active elements of the social relations superstructure which derives from the means of production. These ordinary behaviors shape our worldviews, our semiotic codes, our lives.

Ordinary behaviors related to labor and production include the habitual acts that are part of having a job or not having one (See Figure 3.9). Various labor scenarios can be further decomposed into more detailed ordinary behaviors. In corporate America, these might include the weekly status meeting, the push to meet a major deadline, and the annual performance review. In academia, for students, ordinary behaviors include participating in the first week of classes, midterms, finals, and the thesis defense; for teachers, they include the preparations of syllabi, faculty meetings and tenure reviews. Graduation, itself, is a restored behavior, often complete with rehearsal, a pure ceremony.

Ordinary behaviors which are part of consumption involve consuming both material and pure sign value products. There is shopping, a form of direct consumption, exchange of money for objects. In America, hanging out at the shopping mall is part of many adolescent rites of passage; going there to buy things for Christmas, and on various contrived shopping holidays like President's Day, is also ritualized. Consumption of media is typified by television, and many Web sites. Here, instead of exchanging money directly, the consumer "pays" for the content by giving her/his attention to advertisements, that is, to the marketing of brands.

3.3.3. brands connect restored and ordinary behavior

As brands are at the heart of the production and consumption of sign values, so the experience of knowing them is emblematic of information age ordinary behavior. Brands are the sustained media content experiences of postmodern life. Brands have a longer lifetime than movies or television shows; in many cases, they continue beyond the successful periods of particular authors, actors, or bands.[10] We interact with brands through advertisements in all media, as well as through branded products. Thus our experiences with brands can also cut across more aspects of life than particular media products. As so many of our postindustrial activities are situated more in the midst of multinational capitalism, than they are in a particular locale, so brands take on a role akin to that of the local bard.

Like labor and production, consumption is significant routine. “Programming” is a font of normalized behaviors, presented as sign values. Brands come to the fore as a locus of significant behavior. Their function straddles restored and routine. While consumption is generally quite routine, the advertising agency is very much a corporate shaman. Extremely successful agency “pitchmen” are even called “rainmakers.”

The development of a brand, through multiple media, includes the repetition and refinement of material which is characteristic of restored behavior. Self-referential, postmodern semiotic strategies are deliberately employed. For example, the recent Sprite, “Image is nothing. Thirst is everything,” campaign parodies the form of brand promotion. Some ads feature NBA star Kobe Bryant. He talks about basketball, and then asks, “Why should you listen to me about what you’re going to drink?” Another ad in the series features an ad agency team conducting a meeting for an absurd yet believable product tie-ins to a slimy sci-fi creature, “Death Slug.” All the parts are completed but the incidental: the script for a Hollywood feature

[10] Authors, actors, and bands also function as brands. That is, they are signifiers, whose signifieds are a line of media products, perhaps including spin-offs.

film. This "episode" ends with the series tag line, "Image is nothing. Thirst is everything." The design of repetition by the "ritual specialists" in the evolution of this form is clear.

The consumption of brands is everyday, and substantially all-encompassing. One way to look at the life of an individual who is "properly" participating in society (that is, one who is doing whatever is necessary to have money and stay out of jail) is as a series of purchases. The clothes we wear, the furniture in our houses, the computers on our desks; these are objects and signs. Their function is subsumed by their sign values. We represent ourselves to society through this set of purchases. I imagine that if I walk two blocks from my Greenwich Village apartment to SoHo on a Saturday, and do fieldwork in the crowded stores, I will find that some people even think about shopping as ritual behavior that they work on and refine. For others, it is purely routine behavior, a necessary and important chore. That consideration of the sign values of branding by consumers during the process of shopping may be more or less liminal does not diminish from its significance. Unlike the theater and ritual behavior that Schechner discusses and the social dramas of Victor Turner, the consumption of brands is a mass phenomenon. Ironically, a survey, conducted for Adweek by Alden & Associates Marketing Research in the wake of the Bush-Gore election, found that 92 percent of adults trust brand ads more than political ads. [Dolliver 2001] This indicates the extreme power of brands in the semiotic mix, and the role of their consumption as sign values in cyborg ecosystems. Notwithstanding this self-congratulatory poll, the consumption of brands is characterized by alienation between producers and consumers, rather than by participation of members of a community. Schechner talks about awareness as part of the mental process of creators of restored behavior, that they are refining “material.” In such

Figure 3.10 The multibranching 2nd order sign system diagram for Nike’s *Mrs.Jones* series includes an inverted component, the signified concept. The Swoosh is so impregnated with meaning that it stands for products which do not appear.

Nike employs a range of semiotic constructions in its *brand strategy*. They have created several series of ads which employ 2nd order sign system principles. Some of these advertisements do not even sell products, per se. They just create associations with concepts, with a focus on the Nike brand. One series on television during 2000, “Can You Dig It”, features an African-American woman, U.S. Olympic track star Marian Jones (See Figure 3.10). “Mrs. Jones", as she is identified, appears without athletic garb, as the cool sister in a radio studio. She is the rapping DJ who uses black power jargon. The ad works to associate that milieu with the Nike brand, as represented by the Swoosh. There is no explicit focus on athletic shoes, the Nike product. In fact, Nike shoes do not appear directly, and there is no verbal mention of the brand. In this ad both 2nd order terms –not just the signifier – are nested. In the root of the signification chain, a fast cutting sequence montages tape recorders, a phonograph, vu meters, newspaper headlines, Mrs. Jones the DJ, and Mrs. Jones watching television. Mrs. Jones is wrapped in the signification of high technology and popular media, while she raps the words of “the people”. The first order sign system establishes that she is cool, and powerful. This sign, the cool Mrs. Jones, is cast as the form, or signifier, in the 2nd order system.

Only at the very end of the ad, does the Swoosh appear. Yet, the Swoosh, itself, is the key signified in the second order system. How strange: what starts out as a straight forward signifier, can act as a signified. The ad functions by imparting the image, that is, the meaning, of Mrs. Jones the DJ onto the Swoosh. Through the power of ongoing Nike branding, the swoosh refers to an unseen referent: Nike shoes, and other Nike products. The myth is that the brand is cool like Mrs. Jones, so the products are cool ; so, if you wear them, you are cool. Mrs. Jones will be with you. There is a push to elevate wearing Nike from an ordinary, to a restored behavior. In this second order sign system, both the signifier and the signified are nested components. The function of the signifier, or form, follows the typical myth system template. The signified, or concept, is constituted as an inverted sign system component, a signifier whose signified is not visible on this occasion. The bracketed signifier functions nonetheless. Thus, the concept, itself, like the form, is a nested sign.

What is the relevance of this object oriented semiotic recursion analysis to interfaces? In particular, why do sign values, branding, and ordinary behaviors matter? The Internet is a sign. The construction of its meaning is as much a matter of the significant behaviors transmitted through branding strategies, and their powerful advertisements, as it a matter of tangible manifestations. Indeed, since much of the web, itself, consists of advertisements, they are part of, not separate from, human computer interfaces. As with TV, the positioning of brands takes center stage in our experience of the Web medium, in its structure, and its development. Technology is, simply, one of the many factors in the definition of the Internet. Then, there is the economic component, which, as we have seen through the stock market example of Section 3.3.1.4, is also substantially a matter of sign values. The performance of technology and dot com stocks directly impacts the economic development of the Internet, which has become the primary reference point for research about and public experience of human computer interfaces. The perceived viability of business models, particularly their ability to deliver *value add* to the positioning of brands, plays a determining role in what gets funded, and thus developed. Internet consulting and market research powerhouse McKinsey reports that, "… on the Web, the experience is the brand." [Dayal et al 2000: 44]

Furthermore, intercultural projects, including those based on tradition, are inevitably carried out in a context/environment, that is, as part of a prevailing ecosystem. In all cases, multinational capitalism is economically determining. When I was in Ghana and The Gambia in 1994, I felt like *I* was a signifier, and multinational capitalism, in the form of America, was my signified. People associated me with images from whatever commercials and programming they had exposure to, primarily through CNN. The significance of the operation of brands was inescapable. Similarly, the interactive technoartist Natalie Jeremijenko remarks that when video from her Suicide Box installation[11] was played at the Whitney Biennial, people's most consistent comment was, "Look, it's a Sony!" [Eldridge: 2000] The consistency of the experience of branding raises its sign value. Thus, by inductive methods – that is starting from the practices which arise from experience and moving to understand the factors which arise – as well by deduction – starting from the structure of political economy conjoined with semiotics and then considering the context of the interface – the role of brands as harbingers of significant behaviors and sign values in interface research and development is clear.

[11] Suicide Box is a camera with motion sensors on the Golden Gate Bridge, in San Francisco. The sensors notice the motion of people jumping off the bridge, and thus trigger video recording of suicides.

3.3.4. postindustrial and postmodern

As the information age follows the industrial age, so, *postindustrial* is an equivalent designation of this period of history. A third synonym is *postmodern*. The modern era was characterized as an age of innocence, in which the transparent, normal interpretation of the signs of progress and technology was to assign them divine power. Technology promised to deliver mankind from degraded conditions, to solve all our problems. The modern age was the time of the great masterpieces, by artists such as Matisse, Picasso and Stravinsky. In the postmodern period, people realize that corporations are just as likely to layoff senior workers, as to take care of them. Artistic masterpieces are replaced by works based on the principles of found objects and collage, from Duchamp to Eminem[12]. So, the Dada move to replace masterpieces was successful on the first level. However, the underlying goal of replacing superstar branding (in this case, of master artists) was not at all effective, as evidenced prototypically by Andy Warhol. Warhols's work was all about "art" as sign value. The cue for all of this came from Duchamp. *Fountain*'s exploration of the role of context in the interpretation of a work can be seen in a different light: the readymade, however physical, functions primarily as an information artifact. Again, historical ages overlap. Like culture and ethnography, the rise of readymades and Dada was another indicator of the dawn of the information age / postindustrial era / postmodernism.

[12] This rap star was *Rolling Stone*'s 2000 artist of the year.

3.3.5. structural dynamics

Thermodynamic processes effect the distribution of molecules into gaseous, liquid, and solid states. Geological processes result in rock and geographic formations. Biochemical processes distribute energy and waste. The flow of genetic codes effects the evolution and distribution of species. Similarly, in interface ecosystems, economic, political, social/cultural, and technological process dynamically effect fluxes among semiotic codes. Systems of representation are subject to processes of formation, development, and evolution. Some processes foster the development of diverse heterogeneous populations. Others reduce diversity by enforcing standardization and other uni-forms. Prevailing modes may be characterized by stable and unstable states. Transitions between states are often pivotal. Feedback is a fundamental building block.

3.3.5.1. feedback

> When the phenomena of the universe are seen as linked together by cause-and-effect and energy transfer, the resulting picture is of complexly branching and interconnecting chains of causation. In certain regions of this universe (notably organisms in environments, ecosystems, thermostats, steam engines with governors, societies, computers, and the like), these chains of causation form circuits which are closed in the sense that causal interconnection can be traced around the circuit and through whatever position was (arbitrarily) chosen as the starting point of the description. In such a circuit, evidently, events at any position in the circuit may be expected to have effect at all positions of the circuit at later times. Such systems are, however, always open .. in the sense that events within the circuit may be influenced from the outside or may influence outside events.
>
> – Gregory Bateson, *Steps To an Ecology of Mind* [1972: 409-410]

The circuits that Bateson describes are known as feedback loops. Feedback is a form of recursion. It involves taking the output of a flow and adding some of it back to an earlier stage of the same flow. In general there is at least a small time delay in the loop, so what is added or subtracted is actually the value of the signal[13] at a slightly earlier time. Feedback is the basis of regulators, that keep a signal stable by continuously subtracting some of it.[14] This is *negative feedback*. Feedback is also the basis of explosive devices, wherein a chain reaction intensifies as it progresses. This is *positive feedback*. Positive feedback increases the effect of changes (in whatever direction), and thus pushes a system towards extremes, that is, towards boundary conditions. Negative and positive feedback may be combined in a system; for example, stable oscillators can be built by putting a resonant component into the midst of a regulated positive feedback loop. All feedback systems require energy as an input. Such systems transform the energy.

An everyday example of negative feedback is found in the operation of household thermostats. To use Wiener's language [Wiener 1948: 97], the thermostat consists of two functional components: a *sensor* monitors the temperature, and an *effector* makes changes to some part of the system in response to certain data from the sensor. In the cold New England winter, as I write, when the air in my house gets colder than a certain threshold value, the sensor signals a relay on my furnace. This effector opens a valve. Oil flows into the burner, water is heated, and pumped through radiators. After a time, the air gets warmer than a certain threshold, and the heat turns off. This negative feedback loop stabilizes the temperature in my house. Notice that there are two thresholds. The one which triggers the switch on must be at a somewhat lower temperature than the one that triggers the switch off, when the house is "warm enough." This is true, even though I only set a single

[13] A signal is a value that varies over time. It is a function f(t,..).

temperature value through the system's interface. There is a "dead band", wherein the system ignores the fact that it already as warm as I set it for. This *hysteresis* prevents the system from going into rapid oscillations of on and off. Such oscillations would be disconcerting and inefficient.

Positive feedback of an annoying variety can arise in audio P.A. systems. The signal from a microphone is amplified and projected through speakers. Depending on the configuration, the signal through the mic may pick up so much of the signal through the speakers, as well as content like a voice, that positive feedback may overload the system, causing an annoying howl. The howl will generally occur at one or more resonant frequencies. Careful alteration of the physical arrangement of the transducers – both relative to each other, and to other acoustic components, such as walls – may fix the problem. Another solution may be to put a tuned equalizer, or bank of filters, into the feedback loop. The tuned filter(s) reject gain at the resonant frequencies, and so increase the gain which can be sustained throughout the rest of the spectrum before the onset of positive feedback. The resonant frequencies and gain threshold without positive feedback are characteristics of the system. Unchecked, acoustic feedback can push through the boundary conditions of safe operation for any of the components, effectively destroying them.

Positive feedback has been involved in the recent swings of the market with regard to technology stocks, especially, "dot coms". I was working as a consultant in1999 for a startup, Ru4.com, I went out with them on a pitch to potential investors at

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[14] Actually, an amplifier must also use regulating feedback, to prevent the signal from exploding.

Goldman Sachs[15]. What was especially interesting to me was the process: the investors hardly understood the company's goals, which, chameleon-like as they were, had something to do with *relationship marketing*. The investors understood even less about the technological, social, cultural, and design factors that were critical to Ru4's success. No, what was most satisfying to them was the extent to which they could understand the company's goals as being similar to those of other companies that had recently received funding. While I lack statistics, I believe this anecdotal evidence is typical of what was happening on Wall Street and in Silicon Valley in the late nineties. While on the one hand, there was this great surge of investment into dot coms at that time, the criteria for it were not based on the functional factors of the cyborg ecosystem that was in operation. Instead, they were based exclusively on a particular set of sign values. New companies were funded based on their ability to code themselves semiotically to resemble others. This was quite different than the dynamics which created the Internet's original surge in productivity (See Section 3.7). Still, these were the prevailing dynamics. Similarly, as I've already started to discuss (See Section 3.x), when market forces started to doubt the solvency of the extreme amount of capital that had been so rapidly invested, earnings and profits, let alone grounded potential, were not necessarily the basis for investment, and thus for stock prices. The new sign – dot coms are overvalued – emerged, and created a positive feedback towards sell off, and lower stock prices. To what extent this ecosystem segment will stabilize, and to what extent it will oscillate, are unclear. That these feedback dynamics are part of the environment in which human computer interaction research, in general, and *CollageMachine*, in

[15] "Goldman Sachs is a leading global investment banking and securities firm." [www.gs.com]

particular, operate, is clear. They directly impact the availability of capital, and the associated conditions. Along with the significant behaviors and sign values that underlie the functioning of brands on World Wide Web (See Section 3.2.3 above), these dynamics are significant aspects of the *CollageMachine* ecosystem.

Both positive and negative feedback loops can cause oscillations, that is situations in which signals swing from one extreme to another periodically. {Fourier Theory} Systems with feedback loops are often characterized by predictable, smoothly varying linear responses under some range of conditions, and nonlinear, discontinuous responses in extreme situations, that is in the neighborhoods of boundary conditions. Boundary conditions are a state in which the properties of a system change extremely; that is, they are thresholds which mark significant transitions. These conditions are characterized by non-linear response. Some boundary states will be momentary; they lead to break down of components and reduced energy flux. Other boundary conditions are sustainable; they are characterized by strong interactions between components in hybrid configurations. Transitions into these states are threshold phenomena of historical significance, which mark growth and evolution. In describing the operation of feedback loops as chains of causation, Bateson was already considering complex, multi-branching, interconnected structures, such as organisms and cybernetic components. In the case of the impact of sign values on the stock market, and the impact of both on the *CollageMachine* ecosystem, strong interactions among components are a source of non-linear response.

3.3.5.2. scales of space and time

Within a complex system, different feedback loops may operate concurrently at different scales of space and time. With regard to space, in the human body, we consider the molecular scale of biochemical processes, such as metabolism, the flow of blood, and the immune system. On the scale of a singe human body, the functional components include organs, bones, muscles, and the senses. Proceeding outward, a person interacts with others in a conversation, in a building, in a city, on the planet. The 1977 Eames movie *Powers of Ten* captures the phenomenon of multiple, related scales in space. Vision systems use multi-scale "pyramid" decompositions of a scene to conduct analysis. Recursive algorithms start work at a coarse scale (low res); when they find an element of interest, they can "zoom in" to high res, and continue work with more detail. The same principles are the basis for zoomable interfaces, such as Pad [Bederson and Hollan 1994, Perlin and Fox 1993].

Time may also operate on different scales in a single system. Humans metabolize food at one rate, circulate blood at another, fight disease at another, and reproduce, at yet another timescale. Time scales contextualize geological, biological, ecological, and historical evolution. And then there is the big bang, and the evolution of the universe. Creating time scale relationships is also the province of music. Rhythm is the systematic grouping of notes according to their durations [Oxford University Press: 1992], or "the movement in time of individual sounds" [Ladzekpo 1995]. Rhythm involves contrasts of stressed and unstressed syllables, which can express experiences of stress in life Temporal relationships are also created in music at the more macro scales of ostinatos (repeated sequences of notes) and themes. Similar temporal scales operate in film.

During the nineties, when usage of the Internet was growing most rapidly, there was the phrase, “Internet time”. This referred to very rapid introduction of new technologies, and their widespread adoption. Widespread utilization of printing presses took hundreds of years. Six years after the introduction of the first Netscape browser, more than ½ of U.S. citizens are “on-line”. [Investor’s Business Daily 7/18/00] In 1995, one could check out “What’s new on Yahoo?” on a daily or weekly basis to keep up with the addition of new Web sites of interest. As of July 2000, an average of 7.3 million pages are added to the Web daily. Not everything about this trend of time scale acceleration is monotonic, however. In the aftermath of Microsoft’s victory in the browser wars, Netscape has gone several years without a major release of its browser. Meanwhile, the phrase, “Internet time” is no longer so often uttered. The pace of technology adoption ebbs and flows.

3.3.5.3. flows

Flow charts are diagrams which represent systems of interconnected components. These maps are made up of nodes – corresponding to components and processes – connected by edges, forming directed graphs. Graph theory assigns weights to the edges, representing magnitudes of flow values between nodes. In circuit diagrams, what flows through the edges are time-varying signals, as in the above feedback loops. In object oriented architectures, flows represent data messages passed and transformed. In cultural systems, the messages which flow consist of signs, of artifacts, of significant behaviors, and/or of capital. They can span many systems of representation. Flows include tightly coupled interconnections of components, in integral systems, such as bodies and appliances, loosely coupled interconnections across networks, and a spectrum of intermediate levels of interconnectedness.

Energy courses through flows. Flows are structure, and they create structure. They form the basis of the relationships which interface ecology explores.

3.3.5.4. hierarchies and aggregates

> The grid is "the ... quickest way to organize a homogeneous population with a single social purpose." … Whenever a heterogeneous group of people comes together spontaneously, they tend to organize themselves in an interlocking urban pattern that interconnects them without homogenizing them... A similar distinction between centralized and decentralized decision-making must be made with respect to social institutions that determine how energy flows through a city – that is, with respect to the city's "distribution systems." There are bureaucracies, hierarchical structures with conscious goals and overt control mechanisms... There are ... small-town markets, self-organized structures that arise spontaneously out of the activities of many individuals, whose interests only partially overlap... Markets and bureaucracies, as well as unplanned and planned cities, are concrete instances of a more general distinction: self-organized meshworks of diverse elements, versus hierarchies of uniform elements.
>
> – Manuel De Landa, *A Thousand Years of Nonlinear History* [1997: 30-32]

Two distinct sets of structural templates can be identified, regarding stratification and diversity, in the organizing principles of a wide range of systems: hierarchies and *aggregates*[16]. Hierarchies are systems whose components are stratified into distinct ranks. In aggregates, components are all on the same level. Aggregate and hierarchical components may combine, both recursively and on the same level, in all possible configurations, forming complex systems.

Hierarchical systems organize their components into distinct subsets of uniform elements. Each subset is on a different level, and these levels are ranked. Examples of hierarchical systems include bureaucracies, social classes, and languages. Among data structures, hierarchies are represented by trees. A tree consists of a root node,

[16] De Landa cites Deleuze and Guattari in calling these *self-consistent aggregates*. The term strikes me as problematic. It is not the internal consistency of these aggregates that needs emphasis. The term *aggregate* , itself, connotes that elements of the set are somehow united, and thus have some consistent basis which defines their association. The existence of some basis for equality among the constituents is what needs to be made explicit.

with n children[17], also known as leaves. Proceeding recursively, by structural induction, each child may serve as a parent, with children of its own. Structure is repeated on each level. The leaves on each level form a rank. Hierarchies are centralized forms; they develop top-down procedures, which concentrate power and homogenize the entities that they operate on.

A bureaucracy is a socio-political hierarchy, in which the differentiation of levels is based on decision-making power. Bureaucracies are tree structures of command and control. The leaves on any level are subject to obeying the orders of a parent node. In a multinational corporation, the CEO reports to the board of directors. The president reports to the CEO. Vice presidents report to the president. Regional managers report to vice presidents. And so on, proceeding down through n levels to the rank and file, by structural induction. Bureaucracies tend to generate formal sets of rules and laws, consistently enforced procedures which govern their behavior.

An aggregate is a non-hierarchical association of diverse elements, all of which are on the same level. It is an equal value association. The elements of an aggregate are somehow bound together; some structure, process, or mechanism sustains their association. They are related components. The data structure which corresponds to aggregates is the graph. A graph is a set of nodes connected by a set of edges; as a generalization of trees, graphs include any possible configurations of multi-branching interconnection between components. The structure of branching between nodes is not replicated recursively; instead it varies from node to node.

[17] n, a whole number.

Thus, the relationships between nodes are multifarious. Even though they are part of a common aggregate structure, the components retain their distinct identities. Processes within an aggregate develop bottom up, retaining variation. Thus, aggregates are heterogeneous structures that foster diversity.

Some aggregates form spontaneously. A meshwork is a *self-organizing* aggregate in which there is significant exchange of energy among the constituents. The binding association is a strong one, based on ongoing, active feedback loops. Early markets are one form of meshwork. Their function is to set the values of goods. Interested parties gather on market day. They exchange goods and/or capital. Prices are set spontaneously by supply and demand. Entities get what they can, or give what they must, in order to complete transactions. Meshworks may support a multiplicity of binding principles, that is of bases for relationships. Various constituents may make different kinds of agreements. For example, even in a market, where there is some unifying basis of price resolution, contracts are generally made between pairs of entities; the structures of terms may differ greatly from instance to instance. During the Middle Ages, the enforcement of contracts created in markets was based on a combination of centralized decision making, and self-regulating mechanism derived from a balance of terror and a sense of mutual advantage among participants. [De Landa 1997: 33]

Note that while De Landa offers medieval markets as instances of meshwork, he qualifies this identification. It is based on the assumption that no entities can control the supply or demand of any important component. Thus, these are "perfect" markets, free of monopoly and oligopoly. Given the consolidations which prevail[18], contemporary markets are more bureaucratic than they are meshwork.

Another example of a meshwork is the affinity group. These are political cells of 5-10 persons formed to carry out political actions, for example, in the anti-nuclear movement in the 1980's. They use consensus process to make decisions without leaders. The basis of formation for affinity groups is common political goals, and personal friendships. Affinity groups are an example of a *self-sustaining* aggregate. They last for as long these two types of binding principles sustain them, in the face of their experiences with each other, with other meshwork entities, and with bureaucracies. Affinity groups may join together in larger associations, known as spokes councils, in order to coordinate larger scale actions. The spokes council is a meshwork of meshworks. Implicit social hierarchies may form along side of such explicit meshwork decision-making structures.

A third example of a mostly meshwork entity applies to various efforts in the free and open software movements. In these software development efforts, the source code which allows modification is made freely available, usually with the proviso that any changes must also be made public. The primary selecting mechanism of who participates in these development efforts, is a matter of who is motivated and skilled enough to create code that others find useful. It is an open, self-selecting process. Examples of free/open software, are Linux, the Apache Web server, and various

[18] I just noticed the incredible monopolies that exist in the market for bottled water. Various east coast brands, such as Deer Park are jointly owned by Poland Spring. Poland Spring, in turn, is owned by Perrier, of France. Perrier also owns the west coast, Calistoga. Furthermore, Perrier, itself, is a division of the Swiss firm, Nestle. The roles of Intel and Microsoft, in chips and operating systems, are quite similar.

GNU utilities, such as Emacs and zip. The first contractual agreement to legally structure the use of free software was the GNU Public License (GP9), or “copyleft”. This was created by the Free Software Foundation (FSF), which was setup under the leadership of Richard Stallman, in order to put forth the model of software development with open access to source.

The copyleft conjoins meshwork with bureaucracy. It is a binding legal contract that the authors of free software impose on the entities to whom they distribute. There is plenty of legalese in the GPL; clearly a lawyer spent significant time developing it. The implication is that in the event of a violation, authors would go to court. Thus, the copyleft for free software produces a hybrid form of meshwork and bureaucracy. An infinite number of such combinations is possible, with widely variable structural forms. There can be meshworks of bureaucracies, and hierarchies of meshworks. In this case, we have a meshwork – the free software developers of a particular software environment– connecting itself to a variety, of other entities – bureaucratic corporations, other meshworks, and individuals – who want to use and perhaps modify the software, through a hybrid mechanism that includes both meshwork – the open source – and bureaucratic – through the contract – components. A number of companies, such as Red Hat and VA Linux, have been recently incorporated solely for the purpose of distributing, supporting, and modifying free software, in particular the Linux operating system. These companies have started up with plenty of venture capital from prominent institutions. Cygnus, a long-time niche company providing support and custom development in relation to the FSF “products”, especially compilers and debuggers, was recently purchased by Red Hat. Meshwork and bureaucratic structures can interlock quickly and deeply.

Other companies have recently sought to harness the power of software development by meshwork more directly . They have created more imposing “open software” or “community source” licenses which require not necessarily making improvements available to all, but to themselves, the parents. This is obviously the root of a tree structure. The software emanates from a bureaucracy, instead of a meshwork; The bureaucracy creates a meshwork structure (to some extent) around the development of some particular software. Examples of this hybrid form are Netscape’s Mozilla Project, and Sun’s JINI.

The flow of knowledge, which is a critical form of circulation in cyborg ecosystems, is impeded by bureaucracies, and sustained by meshworks. As De Landa points out, “Only where patents are perfectly enforceable will information be allowed to flow through markets, else antimarkets will prefer to internalize it into their hierarchies.” [Ibid: 90] Hierarchical subcomponents will also tend to regulate the flow of knowledge within a bureaucracy. Another example of a hybrid is the corporate research lab, which establishes a meshwork inside of a bureaucracy. The first such was created by General Electric early in the twentieth century. [Ibid] More recently, corporate research labs have played a key role in developing information age technologies. Bell Labs created the Unix operating system (OS) and the C and C++ programming languages starting around 1970.[Lucent Technologies 2000] Unix is the prototypical modern OS; with the release of Mac OS X in 2001, it will be safe to say that all commercially prominent operating systems are at least substantially influenced by Unix, and many are direct incarnations. The Xerox Palo Alto Research Center (PARC) has been responsible for the desktop metaphor and the personal computer (the Star and Alto projects, which inadvertently spawned the Apple Macintosh), Postscript (the language basis of most printers, now owned by Adobe), and ethernet, the omnipresent standard for the lowest level of computer networking[19]. Interestingly, neither Bell Labs, nor Xerox, managed to profit significantly from these developments. The dynamic power of meshworks is clear; the ability of bureaucracies to harness that power is perhaps tenuous.

As well as considering instances of hierarchies and aggregates, take a perspective one level out, and consider processes which generate them. One meta-object generating process template, which can produce both hierarchies and aggregates, consists of two stages.[20] An initial stage of sorting entities into distinct groups, is followed by a second stage, in which the entities in each group cohere (substantiate). The formation of sedimentary rocks is an example. Rock fragments erode from mountains; they are moved to the bottom of the ocean, where they accumulate. Rivers act as hydraulic computers and transporters, sorting rocks according to their sizes as they move them. The smallest break down into dust and dissolve. The next size up are pulled easily for long distances, and deposited into piles. Larger rocks may alternate, being pulled for a while, then getting stuck

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[19] Higher level protocols, such as the Internet's TCP/IP, Microsoft's various file sharing protocols, and Apple's Appletalk all run over ethernet.

[20] The ideas and source materials in the following two examples come primarily from De Landa. However, I interpret them differently. Thus, while we are both working in the same domain, I arrive at some conflicting conclusions. For example, for De Landa, the sorting and sedimenting of rivers and species is a "double articulation" process which forms strata, of which hierarchies are a subset. (He does grant that within a stratum, such as a

together in alcoves along the river bed. The largest are briefly dragged from side to side, and more often stuck. Variations in prevailing conditions, such as the amount of water, its temperature, and chemistry, vary the response of this nonlinear dynamic sorting machine.

Some substantial portion of these materials arrive at the ocean, where they are deposited into piles according to size and shape. A second process must now occur in order to transform these sorted sediments into sedimentary rock. Calcite, silica or iron oxides react with the sediments in order to cement them together, to aggregate them. This aggregate is made up of compatible components – the result of the sorting stage. The components can still be identified as distinct entities, within the sedimentary rock that they become part of.

More generally, the sorted materials which result from the first stage cohere in the second stage to form a component. The elements are bound together. Coherence creates an identity; it effects their formation into a sustained unit, which is not easily dissembled. The coherence ensures that this component will retain the characteristics developed in the first stage, as it participates in other dynamic system configurations, at least within certain environmental response characteristics.

Another example of the two stage meta-object generating process template arises in the formation of species. Genes are deposited in response to localized selection pressures, such as climate, the actions of predators and parasites, the development of food sources, and symbiotic associations; that is, genes sediment into localized

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sedimentary layer, a self-consistent aggregate is found.) I, reinterpret this data as the piles, according to the response characteristics of environments. Ordinarily, these adaptive sediments may be re-dispersed across a wider population. Coherence of these loose collections of genes is effected by reproductive isolation. If all of the individuals carrying a sedimented gene configuration are separated from other populations over an extended period of time, a new species may aggregate. Isolation is a coherence mechanism which sustains their evolution.

The two stage meta-object generating process for dynamic, non-linear systems is remarkably similar to geneplore. The "creative" processes of nonlinear dynamic systems are similar to those of human beings. In the first stage, generate possible configurations – perhaps by sorting. Next, interpret them, that is subject them to conditions which evaluate their potential. (This stage is implicit in the above descriptions of the generating processes for sedimentary rocks and species. In those scenarios, the conditions that support coherence may not exist – only compatibly sorted rock piles will cohere, and the proper agents must also be present; fulfillment of the necessary conditions, or lack thereof, constitutes the environment's process of "interpretation".) Then, in some cases, an entity with new properties will emerge. Cognition of this new idea is an example of the coherence stage which conserves the new creation.

The processes which create sedimentary rocks and species have the same 'something appears spontaneously where there was nothing' quality as creativity. And what's more, all of these systems support and generate strong interactions among their components. The concomitant feedback loops result in nonlinear

description of a two stage process for forming entities, in this case, an aggregate.

dynamics. Combinations are created and "considered". The whole is characterized not as the sum, but as the relationships of its parts. Phenomena *emerge*. On many levels, with many entities – including economic systems, languages, geological systems, species evolution, and creativity – dynamic systems principles work to create structure.

Some instances of meshworks which seem particularly relevant to interface ecology are:

- semiotic collage,
- equal value,
- rhizome,
- cross rhythm, and
- semantic network.

3.3.5.4.1. semiotic collage

Section 2.2 establishes semiotic collage as an artistic practice of creative emergence. Collage is a meshwork form of media. By combining found media elements, collage invokes their sign values in combination. The found objects are heterogeneous peers. The artist forms an aggregate through the processes of selection, placement, fastening, and treatments. Energy circulates dynamically through a collage when a viewer engages the work. Each process of interpretation can develop a new combinatorial hybrid from the semiotic blend. Even a fixed collage creates a perpetual semiotic meshwork from the constituent code elements. A collage generating automata, such as *CollageMachine*, multiplies the possibilities.

3.3.5.4.2. equal value

I adopted an equal value approach in Section 3.2.2, drawing from Gertrude Stein's approach to writing. I applied equal value first to the inclusion of disciplines in my formulation, and then to the positioning of voices. I originally posited equal value as an axiom. Now, equal value can be seem as a meshwork-forming principle. Since meshworks are dynamic structures that sustain heterogeneity and develop knowledge, the role of equal value in interface ecology shifts from axiom to theorem. Likewise, the sustain of equivocal renderings, instead of universalizing, also functions as a meshwork.

3.3.5.4.3. rhizome

> A rhizome … establishes connections between semiotic chains, organizations of power, and circumstances relative to the arts, sciences, and social struggles. A semiotic chain is like a tuber agglomerating very diverse acts, not only linguistic, but also perceptive, mimetic, gestural, and cognitive: there is no language in itself, nor are there any linguistic universals, only a throng of dialects, patois, slangs, and specialized languages.
>
> – Giles Deleuze and Felix Guattari, *A Thousand Plateaus: Capitalism and Schizophrenia*[1987: 7]

Rhizome is Deleuze and Guattari's philosophical term for meshworks. A rhizome is quite literally a plant component which is not tree-like. A rhizome is a fibrous, multi-branching root system, with no primary tap root. Rhizomatic root systems are able to dynamically spawn new components of interconnection. These are not children, but peers. As the citation indicates, the scope of rhizomes crosses disciplinary boundaries, creating interconnections. Rhizome is inherently multivocal, developing representative hybrid language forms without completeness.

3.3.5.4.4. cross rhythm

> In an Ã*nlo-Ewe* ... communal view, rhythm provides the regular pulsation or beat which is the focal point in uniting the energies of the entire community in the pursuit of their collective destiny… The technique of cross rhythm is a highly developed systematic interplay of varying rhythmic motions simulating the dynamics of contrasting moments or emotional stress phenomena likely to occur in actual human existence.
>
> – C.K. Lãdzekpo, *Rhythmic Principles*

Cross rhythm, the West African compositional device for composing multiple voices, is another meshwork form. Cross rhythm is one of the underlying conceptual bases both for *CollageMachine*, and for interface ecology. In *Ewe* music, the underlying pulse framework is the unifying principle which binds the aggregate. Through these parts, or voices[21], multiple, contrasting and even conflicting perspectives are expressed concurrently. Each performer's maintenance of the integrity and *feel* of

[21] In Ã*nlo-Ewe* music, the drums actually speak lines of oral poetry.

the underlying pulse framework, through whatever crashings of the voices, is the glue of coherence. Strong and sensitive rhythmic skill among performers is required. This is a form for multivocal expression. Enormous energy of a community or performing ensemble is focused, circulated and transformed by the meshwork form of cross rhythm among Ghanaians, through the media of drumming, dancing, singing, and cloth.

3.4. the fundamental unit of information age ecology

3.4.1. interface: a border zone

> ...Those of us living South of the digital border were forced to assume once again the unpleasant but necessary roles of webbacks, undocumented cyber-immigrants, ... and virtual coyotes... the theoretical vocabulary utilized by critics was … largely de-politicized (i.e. postcolonial theory and the border paradigm were conveniently overlooked); and if Chicanos and Mexicans didn't participate enough in the net, it was solely because of lack of information or interest, (not money or "access")... What "we" desire is ... to develop a multicentric theoretical understanding of the (cultural, political and aesthetic) possibilities of new technologies... Chicano artists in particular wish to "brownify" virtual space; to "spanglishize the net"...
>
> – Guillermo Gómez-Peña, *The Virtual Barrio @ the Other Frontier* [1997]

Even more than *culture*, *interface* is an information age signifier. The first usage, at the tail end of the nineteenth century, referred to a boundary layer between reacting chemicals. Interface was confined to usage in chemical systems until the early sixties. The Oxford English Dictionary cites McLuhan himself as the first to more generally apply the term to a means or place of meeting, dialogue, liaison, or interaction between parties, systems, or disciplines. While this meaning has especially been applied to data exchange in information systems, the dictionary does not limit its scope as such. Our notion of interfaces is rooted in science, and grew in the information age to include the interplay of human beings and knowledge artifacts as configured in various systems. All interface signs point to cyborg.

It is time to use structural dynamics principles to address the implications of the meaning the dictionary offers, and of the popular usages of *interface*. Let me create a new, full-out definition for the term. According to the Greek root, "between fascia," that is, faces; so, dwelling in connecting areas, and encompassing the processes which occur within them. Interstitial. In these spaces between, cyborg components engage in flows of sign values. An interface is a border zone where systems of representation abut. It is a membrane, regulating the exchange of vital messages from one side to the other. The more open the membrane, the more flow, the more new combinations that an interface supports. Particular membrane structures can act as filters, tuning feedback loops.

Crossing borders means exchanging cultures; the border, through its very existence, means that constituents on each side are somehow *different*. An interface may act as a bridge and a conduit; it may act as a fence, as a barrier. One side may be privileged and white; the other, a barrio. An interface may encourage mixing or enforce separation. The crossing may be facilitated in some dimensions, and opposed in others. Interfaces enable access, and they protect. They permit and they deny.

Passing messages across borders requires translation. To what extent is the translation unilateral, bilateral, or multilateral? A characteristic of interfaces is the extent to which one language or another is imposed on participants for whom it its not native. Multivocal positions are extant. Equivocal representation is called for. Instead, universalism is often imposed through seemingly benign, transparent codes of normalcy. Thus, interfaces are sites of struggle. Interfaces conjure meshwork phenomena; when they are conceptualized and constructed narrowly – as science and technology and marketing – by bureaucracies, they are reduced to grids of control. When they are developed equivocally, through ecological processes, they offer the potential of rhizomes branching as deep and wide as the imagination can envision.

Haraway writes, "… the relation between organism and machine has been a border war." Such cyborg borders are interfaces. Their constitution is part human and part machine. The border war is between human and human, as much as it is between human and machine. Machines are generally deployed according to someone's interests. What we are really dealing with is a dynamic system of cyborg components, in which agency is mediated. Machines may be the agents of artificial persons, that is of corporations. While the large multinationals represent the interests of individuals, as "artificial persons", they are cyborgs by nature. Further, their mechanisms of exchange, communication, command and control, and reproduction are built through technology.

On the next level, as I've established in Section 3.1, *culture*, *cultural exchange*, and *ethnography*: these are information age signs. Their existence is a matter of certain technologies, and of certain economic processes. It is a matter of the configuration of dynamic components in this particular period of history. The information age began with the formation of *culture*. *Interface* and cyborg are threshold phenomena that mark its ascendance. That is, in history, c*ulture* walks arm and arm with cyborgs. Thus, all intercultural exchanges are cyborg.[22] All intercultural borders include media and communications technologies as fundamental components; they produce knowledge artifacts; they are interfaces. In Section 3.5.1, I will further develop the connection of ethnography to interface development.

Interfaces tend to operate concurrently on multiple levels. Interfaces reflect and create juxtaposition. They form collages. They are the stomping grounds of mythological tricksters. They function as crossroads. They can open doors to the future; they can tease us if we are vain.

Interfaces are the medium of interaction. Interfaces are composite artifacts, that is, artifacts built from artifacts. They constitute the situations in which representations are presented to and by the user and the developer, the subject and the object, the ethnographer and the other. In an immediate frame, our experience of interfaces is sensory. They consist of media. They employ affordances. An affordance is a sensory attribute of an artifact which, through a user's perceiving it, enables interaction. A well-designed affordance provides clues which show how to use it. Again, these clues are messages, and the languages which form the basis of the messages characterize interfaces.

As we've seen in Section 3.4.x, strong interactions between components push feedback flows towards boundary conditions, that is towards extremes. Activity in the neighborhoods of these boundary conditions may produce oscillations and new configurations. Interfaces may function as great lenses that focus energy. Such activity may produce monumental explosions, or self-sustaining aggregates. Thus interfaces are flash points; they also hold the potential for emergence.

Some people speak of the vanishing of the interface as technology becomes more sophisticated. What they refer to is a situation where the interface is so seamlessly

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[22] This is similar to McKenzie's reasoning: "All performance is electronic." [McKenzie 2001]

integrated with physical reality that it becomes imperceptible. In their idealized form of virtual reality, the interface is so well-executed and the experience so high-powered, that the user forgets it is there. In this, by some parameters, ideal user experience, what the interface provides is a transparent, fully integrated augmentation of human experience. Examples can be found in science fiction: the Star Trek holodeck – a where realistic fantasy simulations may be experienced – or the bio-implants of William Gibson's cyber-punk, which enhance sensory functions and display realtime data from the net directly on the retina. Transparency and fluidity of an interface do not make it any less of a border zone. From the developer's perspective, the work still involves creating a mechanism which serves as a bridge to translate one world's system of representation to another's. Furthermore, while perfect transparency does represent one ideal of how technology can serve human beings, it is not the only possible ideal. In fact, it may turn out to conflict with the design goal of clarity: that an intentionally constructed interface should make its function clear through its working.

3.4.2. interface ecosystems

Ecosystems are heterogeneous, dynamic, self-organizing, and self-sustaining aggregates. Cyber and organic components interconnect to form cyborg ecosystems. These meshworks produce, manipulate, and transform artifacts. Interfaces constitute strategic, connecting edges, both within, and in the case of nesting, between cyborg meshworks. They are pathways that support energetic flows in feedback loops. Even though interfaces seem not to be sites, but connections between sites, the study of cyborg ecosystems needs to focus on them. An interface ecosystem perspective examines a cyborg ecosystem from a frame of reference that is centered on an interface. The zones of overlapping, rather than the entities, are primary. This referential frame emphasizes flows, edges rather than nodes, processes, rather than products, dynamic structures instead of particular transient states. Inasmuch as edges support exchange between heterogeneous nodes, they form regions of contact, activating collage principles. In this way, interface ecosystems effect cutting, pasting, and the concomitant processes of recontextualization, translation, and interpretation. Such exchange can catalyze the formation of semiotic hybrids, as signs circulate through ecosystem pathways. The emergent hybrid representational forms may be transient or sustained. These are new species of meaning. Interface ecosystems are the fundamental unit of information age ecology.

Depending on the location from and role in which an entity is positioned relative to the border zone an interface delineates, that interface looks different. From the point of view of an ecologically oriented developer, an interface is an interpretive translation – created with media and representing cultures – that draws from disciplines in its construction, to carry meanings through a border zone. From the point of view of those who receive it, the interface *is* the border zone; it is a media manifestation that represents culture from other perspectives around and amidst the border, offering and/or denying translation and traversal in various aspects.

For the biologist, Evans, the "medium through which energy is circulated, transformed, and accumulated," consists of "living things and their activities." For the semiotician, Baudrillard, "the sign … [is] a total medium, a system of communication administering all social exchange." [Baudrillard 1981: 146] For myself, as an ecologizer, interfaces are the strategic multidimensional loci which circulate and transform signs in the information age. These border zones catalyze and focus cyborg ecosystems.

In keeping with object oriented practices developed above, Evans' definition of biological ecosystem (See Chapter 1.) functions as a template. When re-instantiated with a necessary range of postindustrial concepts, that template forms the basis for composing a new definition of interface ecosystem as the fundamental unit of information age ecology. Thus, an interface ecosystem involves:

• the dynamic interactions of media, cultures, and disciplines, the border zones through which these interactions occur, the voices represented, and the hybrid forms that emerge;
• the roles of human beings and cyborg components – such as corporations, markets, information artifacts, semiotic codes, telecommunications networks, computers, and presentation media – and the flows which connect them;
• the technological, socio-cultural, political, and economic processes which define, circulate, transform and accumulate sign values, and the concomitant significant behaviors through which people manipulate and are manipulated by signs.

3.4.3. interfaces: implicit and explicit

```
interface    =   dynamic interactions of
ecosystem        media, cultures, and disciplines
```

Equation 3.1

What does it mean to broaden the scope of *interface*? Aren't the interactions of disciplines, culture, and media something else? Consider the case of artifacts which we were already calling interfaces. Human computer interfaces are an example of these *explicit* interfaces. When cyber, organic, and hybrid entities interact, they exchange messages. The messages are represented by media; they are based on and contain cultural perspective; cultures form the ground of meanings, that is, the context, in which they occur. A process of translation between cultures, and their semiotic codes, is required. An interface translates messages from one semiotic code, to another. The interactive artifact – which, itself, is already an integrated product of previous interfacing activities – mediates exchange through the interface, across a border. Most immediately, the computer is on one side of the border, the *user* is on the other. Behind the curtain of the computer, dwell the interface designer, and the designers of the layers of the underlying platform. Each of these actors may work in a different cultural context. These add dimension to the ecosystem, which can be manifested as nodes and flow pathways. The study of such an interface is the matter of disciplines, which is to say that as soon as one considers its range of implications and effects, a multiplicity of disciplines are invoked. Yet, the range of cultures and disciplines which are dynamically involved in such explicit interfaces are often not considered. The factors are often not specified in statements of work and requirements documents, nor in prevailing expectations. Equation 3.1 makes explicit these implicit factors, which always operate in the context of interfaces.

Consider, as well, the case of intercultural, intermedia, and interdisciplinary work. Here, while the systems of representation, or factors of interaction, may be explicit, the notion of interface is likely implicit. Yet, they all involve “meeting, dialogue, liaison, or interaction between parties, systems, or disciplines,” as per the dictionary denotation for interface.

To see this in practice, let’s look first just at the potential for interactions between media. For example, take Web pages – hypermedia. As soon as you put text and interactive hyperlinks together, you get new possibilities for representation. Adding just images increases the possiblities, dramatically, as if by a new dimension. This was seen when the Mosaic browser was introduced in 1994. The incorporation of images in broadly available hypermedia initiated the exponential growth in users of the form. With the addition of rich media – video, 2D and 3D animation, sound – the result is the combinatorial expansion of a space of possible combinations. The combinations make take the form of weak aggregates with minimal interconnections, or strong meshworks with intricate interconnections may be built. Hybrid semiotic encodings arise directly through the processes of relating the systems of representation – through intersemiotic translation – and of developing the interconnections – ecologizing. This is the fundamental characteristic of interface ecosystems.

Both explicit and implicit interfaces involve message passing across borders. They involve processes of exchange and translation. When structural dynamic factors are taken into account, implicit and explicit interfaces are equivalent.

3.5. ecologizing = doing interface ecology [interlude 2]

So now that we know what interface ecosystems are, what, then, is "doing interface ecology"? What is it to ecologize? Two modes of practice – which can be called analysis and synthesis, or descriptive and generative – are fundamental. While these modes seem to be binary, in fact they turn out to be practically inseparable. A range of processes arise through the practice of these modes, including and expanding on existing processes in constituent fields, producing yet more hybrids.

3.5.1. modes of practice

Interface ecology frames an evaluative and generative meta-structure. This framework forms a basis both for descriptive functional analysis of the connections between systems of representation in interfaces that people are subjected to, and for development of connections between systems of representation through interfaces that we create.

3.5.1.1. analysis – descriptive – investigative

The analytic mode of interface ecology practice consists of the investigation and thick description of interface constellations, and their components. Interfaces are situated in particular sites and locales; particular significant behaviors are performed there. This analysis examines processes which are apparently happening, in motion, without the ecologizer's intervention, and their components, such as events, dramas, political positions, economic conditions, social formations, and culture. Recursion analysis and the tools of structural dynamics are applied. Significant behaviors are related to the formation and transmutation of signs. Roles are identified. Territories and organizations are mapped. Feedback loops are observed. Flows are charted. The goal of this mode is to identify and understand interface ecosystem dynamics. In this way it includes various forms of criticism; including literary criticism, communication, performance and cinema studies; social science, such as economics, political science, sociology, anthropology, and ethnography; the history of science and philosophy; and descriptive forms – that is, everything other than research – of mathematics and computer science.

3.5.1.2. synthesis – generative – creative

The synthetic mode of interface ecology is generative. While breaking down the barriers between disciplines, connecting analysis and creative synthesis is another natural step; their separation is likewise artificial. The full spectrum of creative activities – including authoring, performing, design, and “fine” arts, as well as scientific research and engineering – is included. As ecological development is situated, so, any such synthesis is performed in the context of analysis. Theory and practice are thus connected. This approach stands in sharp contrast to, for example, performance studies, which explicitly excludes the practice of drama from its domain, and cinema studies, which likewise excludes filmmaking. The existence of this separation is a matter of the history of disciplinary bureaucracies, rather than of the structure of practice. Likewise, the separation of the technological from the creative is artificial. Precedent dates back to the ancient Greeks, for whom *techne* – the root of our technology – included artistic practices, along with scientific study. Likewise, in the WWW ecosystem, fault tolerant protocols, sign values, and design are inextricably linked. In Anyako, master drummers happen to be skilled, at least, in the maintenance of drums, if not in their construction. This is a practical necessity. The craft of drum skins and coopings is not at all simple, either. Unlike the interrelated components of activities in the center of multinational capitalism, drum playing and maintenance do not happen to be inconveniently distributed across remote departments or divisions, under entirely separated management. The structure of those bureaucracies – and of the concomitant biases which have been instilled in generations of practitioners who work in and have been educated by them – should not interfere with investigating phenomena as they actually occur, and thus developing the meshwork structure of knowledge. The imposition of a grid that separates practices of description and creation interferes with the workings of a structure which is meshwork by nature.

3.5.1.3. ethnography <-> hci strange loops

The descriptive and generative modes of interface ecology turn out to be indivisible for deeper, as well as these prima facie, structural reasons. The inherent convergence of these two modes of practice can be developed from two more directions. Either way, ethnography sits at the fulcrum, as the pivotal linkage in a strange loop. From one direction, start by examining the practice of human computer interaction (hci) development, and consider it in ethnographic terms. From the other, examine the practice of ethnography in the context of the information age. In both cases, the conclusion is the same: description and creation are inseparable.

A series of developments has positioned ethnography strongly amidst the practice of hci. Norman's *user-centered* design, while it raised important principles[23], did little to define a mode of practice. How do we know what the user's conceptual model is? To answer these questions, hci began to acknowledge its roots in ethnography. Lewis and Rieman's [1994] *task centered* design locates interaction design squarely in work practice. In order to practice task centered design, developers must acquire in-context knowledge of the tasks that user's do, and the conditions under which they do them. Thus, anthropological methods, such as observations, interviews, and questionnaires, were brought into the mainstream of hci practice. Suchman further articulated the connection of interfaces to context, by showing that the steps people take in the process of accomplishing tasks are *situated actions*. [Suchman 1987] She then focused the work of a number of anthropologically oriented hci practitioners around "representations of work" – a range of artifact forms that aid the development of, and ultimately include human computer interfaces. Sachs (See above), who was working inside this rubric of work practices, nonetheless expanded the scope of investigation from task-centered to activity-oriented, by including implicit social dimensions of human relationships, along with task requirements. She found that informal social interaction was an essential part of how people got work done, and that focusing only on tasks could hide tacit, informal associations; disrupting these social processes, in her case, meant disrupting work.

[23] Actually, what Norman does not mention is the irony of this formulation. If interface designs were not user-centered, who would they be centered on? The impact of this articulation, the changes it brought, says a lot about what the prevailing significant behaviors were, among scientists and engineers involved in the development of interactive artifacts.

These preliminary moves towards ethnography in hci practice arose innocuously, because cultural anthropology held the solutions to some problems that hci was facing. The crash course that the fields are on is exposed by recursion analysis. Interaction designers have been drawn to use ethnographic methods because human computer interfaces are an instant recipe for creating "otherness." The developer works in one context. The user works in another. The interactive artifact creates a relationship between them. The developer needs to understand the user's context. Or users' contexts, as a user population may turn out to be more or less heterogeneous. Participatory design may mitigate this separation between investigators and their subjects, as emic anthropological accounts do, but neither will eliminate the inherent structural divide. Human computer interfaces create the structural relationship that cultural anthropology and ethnography were designed to handle. This is why thick description and associated ethnographic methods are an integral part of hci development.

Concomitantly, all the thorny issues that postmodern ethnography confronts apply to the contexts of its application to hci. Yet, they have not previously been raised in the literature, which so far postures to apply ethnography straight-forwardly in the service of problem solving. I can only imagine that Suchman, who cites Geertz, refrained from raising them out of fear. I imagine that it must have been difficult to get the scientifically oriented hci discipline to accept the basis of a social science at all. In any case, as reported in Section 3.2.3, the hypocrisy of the modernist, objective frame of perspective was exposed decades ago. Geertz didn't just give us thick description, he acknowledged the essentially interpretive (not objective) role of the ethnographer. Clifford et al took the process further: the act of ethnography is a creative literary act. Building interfaces, doing activity-oriented interaction design, these, by Geertzian logic, are interpretive practices, in search of meaning. While usability tests, for example, can provide useful validation, their scope is inherently limited by subjective frameworks of interpretation through which thick descriptions, as well as associated creative processes, are cast.

This intimate connection between thick descriptions and creative processes is the seed for the approach from the other side that begins with ethnography. If an ethnographic text is literature, if it is a fiction of sorts, what separates it from an interface? Very little. Both are creative artifacts. The nature of "text" is gracefully extended to include a full range of media. Thus, an ethnographer does more than "write culture down." S/he also records it, edits it, and hyperlinks it. An ethnographer *represents* culture.

Looking deeper, intent is a differentiator. That is, a description does not seem to be intended to alter the circumstances of its subjects, only to inscribe them. Nonetheless, descriptions may alter circumstances, depending on who reads them, under what circumstances, and how the readers respond. An interface, meanwhile, *is* intended to support activities in some environment; it is intended to become part of, to function actively within an ecosystem. In this sense, building an interface is a form of situated, *thick creation*. The extent to which a text/interface is more thick description or thick creation depends on the extent to which it is intended to effect the environment in relation to which it is produced. From a conceptual point of view, the process and products of doing interface ecology are part of a continuum, from thick description to thick creation, based on the extent to which they intervene in the subject environment; that is, the extent to which they effect the dynamics of the subject interface ecosystem.

From a processual view, amidst the practice of ecologizing, thick description and

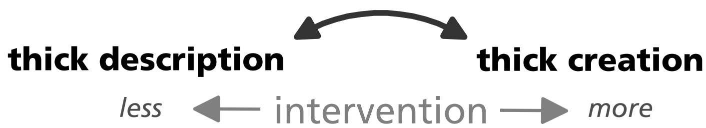

Figure 3.11 Conceptual continuum from thick description to thick creation, based on extent of intervention.

thick creation have a different relationship. Activity-centered development is conducted by iterative design. Projects proceed from initial ethnographic inquiry, to specification, to the design of prototypes of increasing sophistication, to the development of final systems. Throughout this process, interchange with "users" is essential. Such feedback may uncover a fault in earlier stages. These discrepancies between the designer's intent and the user's perception are Norman's gulfs.

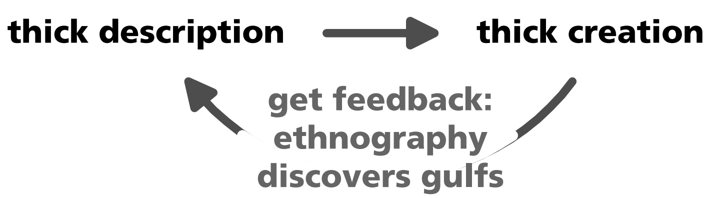

Figure 3.12 Processual view: the feedback loop of iterative design. Thick description leads to thick creation requires more thick description, and adjusted thick creation.

Discovery of gulfs requires return to the appropriate stage of development and refinement of that description, model, or prototype. After going back as necessary, such changes must then be propagated forward into more refined artifacts. Thus, on-going processes of thick description become the basis for further thick creation. Figure 3.12 charts this feedback loop.[24]

What all of this leads to, one way or another, is that an ethnographer *creates* knowledge artifacts. They may be text; they may be video or audio recordings; they may be interactive. And this is where the limited scope of Clifford's analysis, for all its power, become apparent. Clifford and his colleagues engaged in what they called *reflexive* ethnography; that is, they applied ethnographic methods to analyze the works of other ethnographers. However, they conducted only the first steps, and not the subsequent recursion analysis, suggested by this self-reference. Since one is applying ethnographic methods to them, it is clear that those ethnographies are, themselves, cultural artifacts. And furthermore, that the ethnographer's own analysis is, likewise, an artifact. What culture do these artifacts represent? Aside from, and more generally than, any particular subject, they represent the disciplines of cultural anthropology and ethnography. They represent multinational capitalism and the global village. The subject culture is not separate from the all-encompassing multinational context; it is part of it. No ethnographer or meta-ethnographer operates from an independent frame of reference. Any modicum of "as if" separated obfuscates. The subject – discourse dichotomy is an artificial hierarchy. This hierarchy, itself, is the source of the objective voice which thwarts equivocality. What is produced is not an account from an external frame of reference, but an ethnographic artifact that is nested into the prevailing system, as it is produced. This paper and the Interface Ecology Web are part of the same ecosystem that they

[24] Thanks to my hci student at Tufts, Jason Jho, for suggesting this alternative diagram perspective.

describe. The *Coded Messages: CHAINS* web site, and articles about it, as well as C.K. Lãdzekpo's site about *Ewe* drumming, effect the Ghanaian contexts which they describe. The descriptive ethnographic artifact and the subject to which it refers are inherently connected in a strange loop of reference. They are part of the same ecosystem. By extrapolation along the thick description – thick creation continuum, the same recursive structural relationship connects an interactive artifact and its contexts of use.

3.5.2. processes

This small catalogue of interface ecology processes is inevitably incomplete. Structurally, that is the result of interpretation, of the vocal limit principle. Anyway, these are some processes that occur to me now as important to mention. I hope others will add to this on-going work in progress.

3.5.2.1. the range of activities: interfaces of work and play

> I want to reassert the importance of scientific evaluations. We must get past the argumentation about my system being more friendly than yours or more natural or intuitive, and talk about user performance. We can deal with satisfaction also, but please focus on user performance and realistic tasks. Please, please, please do your studies – whether they are controlled scientific experiments, usability studies, or simply observations, and get past the wishful thinking and be a scientist and report on real users doing real tasks with these systems.
>
> – Ben Shneiderman, "Direct Manipulation vs. Interface Agents"
> [Shneiderman and Maes 1998: 60]

Interface ecology traverses more dichotomies, analogous to descriptive/generative. One of these, which I already raised in Chapter 1, involves the range of activities encompassed by thick description with regard to interface ecosystems. According to Shneiderman, every user who interacts with a computer is motivated entirely by the need to accomplish "real tasks". What is the range of activities which interfaces can support? Browsing, for example, means the impulse of choosing which branch to nibble, as well as the utility of needing to eat to survive. And browsing is only the beginning. When information/knowledge/interactive artifacts, that is, interfaces, are broadly integrated with life, their roles expand. Support for work is a narrow range. Functionalities are not tidy specifications of what obviously needs to be done; they are open territories. Open ended support for creativity is a starting point. CollageMachine is an example of a program which has begun to address this. There is much room to proceed there, and still this is only a beginning. People engage in more than "realistic tasks". What does it mean to provide interactive support for daydreaming? How can computers support spontaneity? Computer games have mostly been approached narrowly. Narrow notions of entertainment, again, are only a small part of the possible range. Computer supported cooperative play is likely to be a larger market than computer supported cooperative work. With consideration of values other than economic ones, it will also be interesting and enjoyable to experience and to work on. These factors motivate an inclusive notion of activity. Research and other creative endeavors in this area will also feedback to supporting work environments. As Sachs demonstrated, activities which do not correlate directly with tasks nonetheless impact their accomplishment. Interface artifacts may support the underlying processes of generating ideas, both by individuals and by groups. Other social processes may be supported, provoked, and catalyzed, as well.

3.5.2.2. next generation interfaces

> The wildly popular graphical user interfaces (GUIs) are an improvement over command languages, but the next generation of user interfaces is already on the way. The aging GUIs with clumsy one-window-at-a-time housekeeping will give way to rapid, coordinated multiple windows. The future will be dynamic, spatial, 3-dimensional, virtual, ubiquitous, gestural, colorful, often auditory, and sometimes immersive. The demand for high resolution multimedia and full-motion video will push the hardware requirements, absorb network capacity, and challenge the algorithm designers.
>
> – Ben Shneiderman, in "User Interface Strategies '94"

There's nothing wrong what Shneiderman suggests here as the "next generation of user interfaces". Indeed, "rapid, coordinated multiple windows" is a good description of what CollageMachine provides. The specified rich media forms and information visualization techniques may be necessary, but they are not sufficient. My problem is with what Shneiderman does not suggest. This prescription is situated entirely in the domain of media technology, as if all the current shortcomings in interface ecosystems are technological. It is convenient to position the drive to develop new interfaces in the scientific realm, where all results can be quantified. However, it is plainly unrealistic. People need interfaces which are responsive, sensitive even. These are fuzzy notions. They are inherently cultural. Diverse embodiments of who we are and what we do need to be represented through and by interface ecosystems. Research towards next generation interfaces needs to take this on. There is plenty of room for scientific and technological development. However, in order to better satisfy diverse human needs, this development needs to be driven by diverse human concerns and perspectives, Modernism is not sufficient. Interface artifacts are meshwork ecosystem phenomena. A diverse range of life activities needs to be supported. In short, science and engineering need to involve other disciplines, such as the arts and ethnography in principal roles, in order to make their work meaningful. Granting organizations such as the NSF need to be cognizant of these needs at the highest levels, in order to avoid wasting money on masturbatory exercises in technological development which are not grounded in the needs and practices of society.

3.5.2.3. motives: science and art

Another dichotomy to span involves the thought processes and motivations which underlie ecologizing. While both involve creating, science and engineering, on the one hand, and the arts, on the other, embody different modes of operation. From the point of view of science, the world is a series of problems to be solved. An artists sees the world in terms of creative possibilities. In practice, this dichotomy[25] results more in a spectrum of possible mixtures, then it does in binary opposition. At one end of the spectrum, doing *science* means:

- forming theories and running experiments to validate them;
- demonstrating theorems through deduction;
- the systematic classification of data and the derivation of principles; and
- solving well-formed problems.

This is top down thinking by and large, in which principles and hypotheses are the roots of hierarchical trees of action. *Engineering* is the application of scientific principles to construct works of utility. Doing engineering is a process of making that begins with plans, and ends with situated actions. Roots include *ingenious*, *engine*, and, ultimately, to *beget*. [Oxford University Press: 1992]

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[25] It would seem that more poles could be represented here. For example, for a business person, the world is a series of economic opportunities. At the same time, both the scientific and business perspectives are rather utility-oriented, while the artistic is more personally motivated.

The concept of beget – as a raw form of creating – is an obvious crossover point between engineering and the arts. Design – an applied form of the arts, as engineering is to science – is another paradigm that sits in the border zone between scientific and artistic practices. Design is the process of giving form to function; as engineering applies scientific principles to build devices in context, so design is based on applying creative principles to achieve specified goals.

Site-specific art is also created with a strong reference to context. Literally, this is art in which a site acts as part of the specification. Such art usually takes the form of performance or installation. *Coded Messages: CHAINS* is an example of a site-specific performance. Francis Kofi, Melissa Lang, and myself chose three sites for the performances: the town center at the remote village of Anyako among the Ewe in southeastern Ghana, the historic slave-trade castle at Cape Coast in the west, among the Fante, and finally, the University of Ghana. A few rehearsals were conducted at the first two of these sites while the material was still being formed, through a workshop process. In Anyako, we referenced the *atigate*, a special tree. We used alleyways as wings, circulating the performance through the entire area, around and amidst the audience. As is the case for traditional performances, there was no stage, per se. In Cape Coast, we had scenes coming out of and entering dungeons. A chase ran along a balcony, above the audience. Tableaus and the "collage" scene were blocked on a parapet, in relation to the colonial cannons. While we used the stage, as provided, it was one of many settings for the performance.

While site-specific art is created in context, still, more generally, art is work in which the motive is somehow personal. The voice, vision, and principles of the artist are represented. While art sometimes involves the beautiful, it may just as well be shocking, or dry. There are many valid approaches. It involves impulsiveness and measured formalism, a wide range of human expressions, utterances, and visages, personal upheavals, elaborate structures, and minimal formations. Art involves melody and harmony, figure and ground; and it also involves their absence. Art may be personal, or it may be conceptual in a way such that a formal process is established, and followed, with a rather dry, and yet illustrative result. Cage's *4:33*, in which a performer sits at a piano for that interval of time without playing, is one example. The background sounds of the room and the audience become the material. The framing of a formal concept hall is a significant aspect. *Yeve* drumming among the *Ewe* is another, very different example; it is intensely passionate, and driving. My performance work, such as *the economic survival rite of passage*, involves collective processes which seek to create social meshworks among performers. On the net, *CollageMachine* creates a meshwork assemblage of web content. In both media, rhythm is involved. So is the creation of a structure in which certain decisions are made in advance, and others are made spontaneously, at what could be called performance time, or run time.

The difference between site-specific art, on the one hand, and design and engineering on the other, is again a matter of intention; it is a matter of the origin of the goals which are enacted. In cases of the latter, usually there is a customer who sets the overall scope of the project, and thus, the underlying goals. Further goals may be derived from interaction with constituents in an environment. In the best of cases, the produced artifact(s) are expected to *support* those constituents in their activities. In the case of site-specific art, the work may intend to *provoke* the audience. It may intend to make a statement, to express a position, or to illustrate principles. These would not be scientific principles, but social ones.

While it may involve "being a scientist," developing interfaces, contrary to Shneiderman's prescription, is much more. Making interfaces is as much call and response as it is solving problems. To use Schon's language, "Increasingly we have become aware of phenomena … which do not fit the model of Technical Rationality." [Schon 1983: 39] The usability and cognitive scientific methods Shneiderman proposes need to be contextualized. Once again, the focus on science renders critical but implicit dimensions of cyborg interface ecologies out of existence. The elimination of critical linkages compresses a meshwork into a hierarchy. One source of this contortion is the sign value mystique associated with science. This, again, is modernism: the exalted notion of science and progress as holding the ultimate keys to humanity's problems. It is the extension of the military industrial complex. When Shneiderman says, "Get past the wishful thinking and be a scientist," it sounds like, "Be a man." There is something macho about it. Wouldn't want to be caught as one of those wimpy artists. In contrast, Mander argues that knowing when to resist science is "a critical survival skill of our time". [Mander 1992: 9] Both Shneiderman and Mander are addressing how to form the processes which shape the role of technology in social contexts. Mander articulates the critical need to include a political process that takes into account social effects as a mandatory part of technology development. The situated contexts that interfaces are developed for is an obvious place to do this. Shneiderman's exalted construction of science, on the other hand, imposes scientific methods and the interactive artifacts they result in on the field of human computer interaction, and on society. While it represents currently accepted standards, and an interest in creating usable artifacts, it ignores such issues as scope definition, context, and creative concepts. Thus, ultimately, it lets users down. Shneiderman pooh-poohs systems that are more natural or intuitive. He is trying to factor out the subjective, which is not possible because interfaces are situated artifacts, subject to interpretive processes of analysis and development. This is why he avoids mentioning the important aspect of how *interesting* systems might be. I agree with the value of referencing "real users" during certain stages of development. Yet, sometimes, I would rather work with the imaginary. Imagination must not be assigned a lesser status in the process of interface development. And because the range of activities is broader than work, sometimes there are no tasks to evaluate. In these cases, there may be no place to hook in the scientific method, or creative cognition methods may apply. Just as creative cognition scientists demonstrated that creativity is a non-deterministic phenomenon that cannot be approached through rule-based systems, so interface development is a creative endeavor that deserves more than to be approached through an inquiry in which top down methods dominate. In positioning artistic methods and motives, let us not forget that the Dada artists were 60 years ahead of cognitive scientists in discovering the power of combinations in creativity. In interface ecology, scientific, artistic, and other methods are blended. The rational, with its method of proof, is only one operative part of any context. If you look sufficiently, the foundations are built from connected components. Values, goals, desires are represented. Restored and ordinary behaviors are carried out. Steps are taken. Assumptions are followed. We respond to the structures of institutions. We make personal choices . These are essential driving energies in the formation and operation of any interface ecosystem. To submerge them beneath a gloss of scientific methods is to hide the essential, in a manner reminiscent of the Spanish Inquisition. Only here, science is the church. The prevailing modus operandi in the field of hci needs to be overturned. The role of *concept* needs to be granted its due credence.

3.5.2.4. concept

> Rational judgments repeat rational judgments.
>
> Illogical judgments lead to new experience…
>
> Irrational thoughts should be followed absolutely and logically…
>
> When words such as painting and sculpture are used, they connote a whole tradition and imply a consequent acceptance of this tradition, thus placing limitations on the artists…
>
> The concept … implies a general direction…
>
> Ideas alone can be works of art; they are in a chain of development that may eventually find form. All ideas need not be made physical…
>
> The concept of a work of art may involve the matter of the piece or the process in which it is made.
>
> – Sol LeWitt, in "Sentences on Conceptual Art" [1999]

Concept is the underlying basis for creative work. Concept specifies what one wants to accomplish, and how it will be accomplished, that is, a sense of desired results, and enabling processes. Applied in practice, concept focuses processes, methods, and goals. Concept substantiates what the artist wants to express, communicate, convey, demonstrate, and/or provoke through a work. Concept may include a sense of desired effect. This sense of effect may be partially concrete and well-defined, partially a feeling, an impression, a sensation. It can be a clear picture or a fleeting vision. “I want the user to be amused by the irony of this juxtaposition,” and, “I want the user to be able to interact with this media element in order to get more similar media,” are two contrasting conceptual sensibilities. Concept may be set in advance and maintained as a project develops, or it may evolve with a project. Together with context, it frames the development process. As a project develops context, a well-articulated concept turns into a tattered map which can guide ongoing decisions. When my sense of concept is clear, it informs ongoing decisions on many levels about design and implementation.

In spite of the fact that scientific research is a creative activity, science’s pretensions of objective practice obscure the importance of framing. The recent rise of “design” within hci demonstrates an understanding that the technical is not a sufficient basis for the field. Yet, that understanding has not been comprehensively propagated into the field’s modus operandi. Ethnography, by establishing a faux distinction between thick description and creation, notwithstanding postmodern moves, has defined itself as a social science. The creative was never separate from either, yet its presence has been relegated to the implicit shadows. Even though it is an important part of scientific research, scientific training also does not directly address the process of concept development.

Concept extends far deeper than responding to requirements specifications and task analyses. The horizon of interfaces needs to be open. The structures of inquiry and the structures of results are meshwork forms by nature. Where do specifications come from? What determines scope? Concept is the font for goals, micro and macro. As Schechner points out, the creative process can be granted the same level of importance as its products. That is, how we work plays a key role in determining our results, and further, we may choose a process to represent our concept, and let that determine the product, instead of vice versa. Tzara, Cage, the choreographer Merce Cunningham, Alan Kaprow (the progenitor of site specific performance events called *happenings*), Schechner, and the visual artist Sol LeWitt are just a few of the many (more or less) *conceptual* artists who have worked from this basis. Treatment of ideas, themselves, as works of art, is clearly another information age bellwether. Conceptual art began with Duchamp's *Fountain*, wherein an object represents a concept; that is, it functions semiotically. As LeWitt illustrates above, concepts are personal; they map artistic intention into knowledge space. Thus, they can embody contradiction and whimsy, as well as logic.

Concept is fundamentally artistic and political. Some scientists and engineers may consider giving primacy to the arts and getting involved in politics to be an affront. It may be scary to move from a mode where everything is rationally justifiable and provable, to one where decisions are based on more than reason. Nonetheless, maximum advancement in our understanding and development of interfaces depends on allowing equal value contributions from different constituent disciplines. Furthermore, the bottom line is that creative and political decisions are made anyway in all processes of hci development. When they remain as unexplored, implicit ecosystem factors, an incomplete map becomes the basis for inquiry. Decisions about what to build and why – that is, concept – are made independently of whether they are given credence. Making concept explicit will strengthen the diversity and power of what is undertaken.

Look at the process semiotically, with the tools of interface ecology. The practice of letting concept be implicit has been an ordinary behavior. Keeping scientific methods at the fore has been a normal practice. Scientific methods have carried greater sign value than those from other disciplines which contribute to hci. The result has been insufficient exploration of the possibilities of what to undertake. Equal value treatment will cure this malady. Giving concept its due, as an essential determinant of results, is a critical step.

3.5.2.5. architecture: sites and navigation

> A site should be a coherent succession of spaces or textures or objects, in which each part relates to the next but in which there is a constant play of variation on the basic theme. A chain of spaces should seem to be part of one extended whole, even while alternating from open to closed, from simple to intricate, from brilliant to subdued.
>
> – Kevin Lynch, *Site Planning* [1971: 206]

The fields of architecture and design also make important contributions to interface ecology. Lynch situated architecture in socio-cultural contexts. He advocated building in relational to situated processes. His language of architectural *sites* translates easily from physical to virtual scenarios.

Alexander also worked in terms of social processes. He coined *intimacy gradient*, to refer to the levels (values?!) of public-ness / private-ness appropriately located in different parts of a house, from foyer to bedroom. These locations host different activities, moods, and feelings. Alexander suggests that architecture structurally support this range.

Intimacy gradients are one conceptually building block from his *pattern language*. He developed this set of reusable design patterns based both on observation and practice. It is an impressive collection of useful components. In some ways, interface ecology is a similar venture in identifying and creating reusable templates. Both correspond to object-oriented programming. However, this work is different from Alexander's in the scope it claims, and the processes it proposes. Alexander trips epistemologically, by claiming that his architectural *patterns* are universal. The vocal representation principle applies here. Universalism is an oppressive concept. A compilation of architectural patterns by diverse people – from diverse cultures, races, classes, and gender orientations – would be more broadly representative. Such a coalition would like agree on some concepts and disagree on others. My goal for this work is not to define a universe. I seek only to initiate a process, which I hope others will participate in.

The value of these architectural viewpoints for the design of interface ecosystems (virtual spaces) highlights the role of navigation. Navigation in the physical world means knowing where you are, where the place you want to go is, and how to get there. Navigation is also the process of figuring that stuff out. Navigation is way finding; it includes reading maps and terrains. Map making itself, like interface development, has always been seen as an objective science, while functioning as an interpretive, ethnographic process, based on situated, local knowledges.

In virtual worlds, navigation takes on an additional dimension, because such worlds are entirely designed. Thus navigation becomes the creation of terrain, as well as maps. Navigation design involves giving people a sense of location, using devices such as visual languages, signs and maps. Navigation situates people; it tells them where the place they want to go is. It orients them. Builders of virtual worlds need to have this kind of sense of place, and of places, of locales, and of routes, in order to give it people. We can also learn about what effective navigation is, both by conducting usability tests, and by examining usage logs. For example, as reported above in Section 2.x, I was very surprised by the siginficance of the order of hyperlinks in how users navigate the outer layer of *CollageMachine*.

Tools such as the Hyperbolic Browser [Lamping et al: 1995], and *CollageMachine* may be referred to as meta-navigation. They provide a means of navigating any web sites. Of these two, *CollageMachine* is more dependent on the navigation provided by the sites themselves, because media elements from the sites, rather than an imposed notation, to represent them. To the extent that the original navigation is well thought out, this is beneficial, because the user interacts with elements of the original look and feel in the collage context. On the other hand, the navigation provided by the Hyperbolic Browser is more globally consistent and uniform.

3.6. the locale of *Coded Messages: CHAINS* – an implicit interface made explicit

ME ME ME ME ME ME ME ME
JUST JUST JUST JUST
vision telephone television tele
Chains of cybernet econo-
ME eco no ME eco no ME e co no
ME eco no ME eco no ME e co no
Hello? What? Are you busy? I should call back when?
Can't you understand? I traveled for hours to reach this tele
phone tele vision telephone television tele
You can't reach me, i got no tele
phone tele vision telephone television tele
vision tele phone television telephone tele

– Andruid Kerne, "Tele", in, *Coded Messages: CHAINS*

In 1994, just before the rise of the WWW, *Coded Messages: CHAINS* juxtaposed the *Ewe* drumming and dancing ecosystem, with multinational sign values as embodied by advertisements, and concept of "cybernet economy". CHAINS is a performance ecology that seamlessly incorporates theater, poetry, music, and dance elements, as meshwork. The goal was to create an intercultural dialogue that explored the tensions involving who can speak and who can understand both within and between the multinational and Ghanaian contexts. Both advertising and drum language are powerful and exclusive semiotic codes. Advertising is a large scale, mass phenomenon, where a small number of people shape the sign values that render people into consumers across the globe. Drum language is also powerful and exclusive. Only drummers are able to speak it. Speakers of the same language will understand it. There are dozens of language groups spoken in Ghana. Most people there are not *Ewes*, and would not understand *Ewe* drum language, unless they had a special exposure to it, through an organization such as the Ghana Dance Ensemble. My composition "Tele," above, is one segment of *CHAINS*. Like many of my compositions, this piece is a form of percussive poetry. It cross rhythmically composes multiple spoken voices. It addresses issues about access to technology, and other signs. "EconoME" emphasizes the selfish, exclusive nature of multinational economy. Unlike in some other pieces, in "Tele", I quoted directly from *Ewe* traditional works, such as *Kpo Megbe* (The Back of the Tiger), and *Gadzo*. The quotes were both on the level of rhythmic passages, and, in some cases, the drum language itself. By quoting directly, instead of just conceptually, I made the work more accessible to the local audiences, who thoroughly enjoyed it. Other segments of *CHAINS* include swaths of unaltered traditional material, as well as additional avant garde compositional and experimental theater techniques. Future research will include more in-depth ecological explication of *CHAINS*.

3.7. Web browsing and searching – an explicit interface

Browsing is a matter of feeding on tasty shoots. Searching is a matter of going around to find something desirable. On the Web, going around means using a browser to get there. So, browsing is part of searching. Meanwhile, inasmuch as one has a particular sense of what one wants to feed on, one is liable to be inclined to explore in focused way to find that forage. Thus, conversely, searching is often part of browsing.

An ecosystem perspective on Web browsing and searching must examine their context in the Internet. Historically, the Internet, itself, has developed through an ecological process. The power of the Internet derives from the strong meshwork structures that have been active in the development process, and which constitute the underlying technology, itself. These meshwork forms developed in the midst of various hierarchies. The hierarchical components of the Internet ecosystem threaten to dominate the meshwork characteristics: which aspects are more fundamental is unclear. The development process was bootstrapped and continues to grow through active strange loops of self-reference.

3.7.1. history of the Internet

What became the Internet – a globally interconnected set of computers providing easy, location independent access to data and programs – was envisioned by Licklider, just as he before he left MIT to serve as the first head of the DoD Advanced Research Projects Agency (ARPA) in 1962.[26] An exclusive network known as the ARPANET grew from his efforts and those of his successors. The ARPANET was the forerunner of the Internet. As the original G.E. research lab functioned as a meshwork within a bureaucracy, so ARPA managed to create a consortium of research labs. This was a meshwork of meshworks that functioned within bureaucracies; it was initiated by the central DoD bureaucracy, as well. The players, themselves, were university labs, such as computer science at MIT and UCLA, and industrial labs, such as SRI and BBN, that provided such services explicitly to the government on a contract basis.

The technology most fundamental to the Internet is packet switching. Packet switching is a means of breaking messages down into small chunks, known as packets. Each packet is independently and dynamically routed from its source to its destination. As network conditions change during the course of a "conversation,"

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[26] Except where otherwise cited, background material for this section comes from Leiner, Cerf, et al, A Brief History of the Internet, [Leiner].

packets may traverse the network via different paths. This contrasts to circuit switched messaging, in which a dedicated circuit is established at the start of a conversation, and statically maintained until the conversation is over. Obviously, the dedicated circuit is less efficient, because it must remain open even when the conversation is quiet, and because its route does not adapt dynamically. Packet switching was first developed by Kleinrock in 1961. His initial paper, “Information Flow in Large Communication Nets”, [Kleinrock 1961] makes a fundamental assumption: nodes in the net are peers. While particular connecting edges are characterized by different flow capacities, it is assumed that all nodes have the same capacity for storing messages that need to be forwarded, and that all edges and nodes can support the same type of flow. Thus, Kleinrock’s packet switched “nets” are meshworks by nature.

Development of the first packet switches for connecting computers was part of the ARPANET initiative. Computers connected as such, by a packet switched network, are known as *hosts*. BBN won the contract to build the first implementation. This implementation consisted of dedicated, specialized, network computer nodes, to which actual hosts could be connected. These dedicated network processors were called Interface Message Processors (IMPs). By the end of 1969, four remote computers, at SRI, UCLA, UC Santa Barbara, and the University of Utah, were able to exchange messages through this network. More followed. While these hosts were all operating under the aegis of DARPA, work on them was not classified. They supported some range of university and commercial research activities.

1969 was also the year in which the meshwork process for the development and publication Internet standards began to take shape. Working groups created proposals.[27] These standards proposals were published in the form of Requests for Comment (RFC). RFCs were publicly available to anyone who knew about them.[28] In 1970, another "working group" defined the first host to host protocol. Implementations came online in 1971-2, enabling the development of reliable applications utilizing remote networking infrastructure. One early RFC was for FTP, the File Transfer Protocol, in 1971. As soon as FTP implementations proliferated, RFCs, themselves, were distributed through this medium. Thus, quickly, a strange loop was formed. The emerging technology was being used as the basis for communicating information about itself to involved participants. The power of this strange loop continues to fuel the rapid growth of the Internet. Another application with the power to connect social and technological processes in a strange loop through the Internet was first developed in 1972: email. The people working on the RFCs, as well as others who had access, quickly adopted email as a means of communication.

The actual hosts in the ARPANET, and the Internet after it, are heterogeneous. That is, they are computers and operating systems made by different manufacturers, that are, in many senses, incompatible. The net provides a translation layer between these disparate platforms. Thus, services can be distributed across them. Network applications interconnect them. The builders of the net have to implement platform specific code to make the network function. Cross –platform standards

[27] While the authors of "The Brief History…" celebrate the openness of the process, it is not clear to me how open actual participation in working groups was.

serve as bridges of translation between particular host platforms, and the common network infrastructure. Independence from platform specifics emerged as an essential component of the Internet's power. Personal computer and operating systems manufacturers, such as Microsoft, Novell, and Apple, as well as proprietary network providers, such as AOL and Prodigy in the 1980's and early 1990's implemented functionality similar to what the Internet provided, but in non-standard forms. They were by and large forced to abandon those systems during the Internet boom period, because the social benefits of a common, platform-independent network infrastructure became clear to consumers. The market found that heterogeneous meshwork organization, development processes, and resulting products are more useful than those that were created by closed hierarchies.

The only exception to heterogeneity in the original ARPANET was the IMPs. Their role as the instruments of packet switching was only temporary. The elimination of IMPs came from a campaign to seamlessly connect not just remote computers, but remote networks. From the start, this was called "Internetworking." The developers considered this drive to heterogeneity as an "open network architecture." Kahn introduced the concept in 1972. In an open network architecture, all nodes function as peers. The technical requirements for more efficient and flexible network infrastructure propelled the development of a more fundamentally meshwork architecture. Kahn and Cerf's Transmission Control Protocol / Internet Protocol (TCP/IP) was the result of this cycle of development [Cerf and Kahn 1974]. The guiding principles of TCP/IP design included fault tolerance for

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[28] In practice, this meant ARPANET users.

messages and routes. To accomplish this goal, it was necessary that there would be no global control at the operations level. The meshwork nature of Kleinrock's theoretical packet-switched networks was implemented in the form of the TCP/IP networking protocol. By 1975, three different otherwise incompatible platforms could seamlessly interoperate through TCP/IP. In 1980, the U.S. Department of Defense adopted TCP/IP as a standard for their networks. Ironically, there is no contradiction in the adoption of this meshwork technology by the world's biggest and most powerful command and control hierarchy. It wasn't until three years later that the ARPANET eliminated dedicated IMPs in favor of peer to peer TCP/IP. Later in the eighties, USENET and NSFNET established a broader basis for commercial and other civilian use of remote TCP/IP networking. TCP/IP is now the absolute foundation of the Internet. In the twenty first century, for computers of all sizes and shapes, a TCP/IP implementation is mandatory. The technology which was originally conceived for connecting networks – internetting – also became the means for computers to be networked as true peers. Design which jumped a level through structural recursion – to networks of networks – had a profound effect on the constituent networks, themselves.

The fundamentally meshwork nature of Internet technology stands in contrast to previous mass media technologies. The printing press is a centralized technology, and so are the channels of mass distribution through which products such as newspapers, books, and compact disks are distributed. Broadcast technologies, such as television and radio, are similar. One (or a few) transmitters feed many receivers. The technology of the net is fundamentally peer to peer. As I write in 2001, a standard PC, with a few upgrades, can serve very well as a high end web and database server. Even bandwidth – the flows of interconnection between nodes – grows more and more affordable. The basis for the Internet to continue to function as a meshwork is deeply rooted.

3.7.2. browsing and searching the World Wide Web

> The … cartographic process is the assemblage of local knowledges…
>
> – David Turnbull, "Mapping the Construction of Knowledge Spaces" [1996]

Through TCP/IP, computers of any kind can function as peers in a meshwork net. Hypermedia, a meshwork form, was layered on top of this TCP/IP base, and called the "World Wide Web". The involved standards include the Hypertext Transfer Protocol (HTTP), for moving files from servers to browsers, and the Hypertext Markup Language (HTML), which defines the structure of the documents, themselves. Berners-Lee's first version of HTML was developed during 1991-1992. The first Internet Draft for the standard was published in 1993. The first really useful browser, Mosaic was developed by Andreessen at NCSA the next year. It became the foundation for the early versions of the Netscape browser that lead the Internet boom during the subsequent years. Developing and publishing Web content enabled widely available publishing of "content" without great capital expenditure in an unprecedented manner.

From the start, Netscape allowed free downloads of their browser, and free use for non-commercial purposes, but charged a licensing fee for corporations. The runaway success of Netscape's browser, and the open standards of the Internet, were perceived as a threat by the most successful corporate bureaucracy of the nineties, Microsoft. Very quickly, during 1995, in a meeting with Intel executives, Microsoft CEO Steve Ballmer reportedly threatened to "cut off Netscape's air supply" by offering a comparable product and giving it away to all customers. [Associated Press 1999] Microsoft did not achieve true parity with Netscape until the release of IE 4, during late 1997. Even before that, Netscape was forced to stop charging license fees for their browser. The end of that revenue stream eliminated their incentive to innovate, and to implement standards of the WWW consortium. Subsequent to an initial three years of rapid innovation, Netscape has not released a significant browser upgrade during the last three.

Hypermedia technology is not the only dimension of the Internet ecosystem in which bureaucratic forces have impeded the growth of meshwork forms. The proliferation of sign values, by large corporations, and their effect on the public's perception, understanding and general sense of the Internet is analyzed in previous sections. The operation of search engines is a subtle example. Search engines, like maps, appear to be objective sources of information regarding the layout and characteristics of a terrain. With searching and browsing, the mapped terrain's basis is virtual. In both physical and virtual cases, maps overlay knowledge representation. Even in the absence of visualization tools, the ordinary hypertext output of search engines maps the Web's knowledge space with regards to a query. Ideally, a search engine indexes the local knowledge of diverse web sites, and makes this index available to users. The problem is that search engines sell keywords to corporate bidders. This puts an enormous skew on the results that are delivered to searchers. The tilt pushes in the direction of increasing the exposure of web content produced by entities with more money. This superimposes a hierarchical structure on the searching and browsing habits of Internet users, in spite of the fundamentally meshwork nature of Web technologies and the underlying Internet infrastructure. The problem is compounded by the mega-portal sites which are accessed by default in the browsers that come with computers and with Internet service packages. While the WWW and its underlying Internet architecture are fundamentally meshwork, forces such as the delivery of sign values through brand campaigns in multiple media, the false objective veneer of search engines, and the herding of naive users through corporate portals push the net toward hierarchical, grid flows of information and power. There is as yet no resolution of this conflict.

Figure 3.x diagrams the Internet ecosystem. It incorporates a number of the salient cyborg components and significant behaviors, as they have been and continued to be defined, circulated, and transformed by technological, socio-cultural, political, and economic processes. Obviously, this picture is incomplete. A more complete model would be multidimensional. The circumstances suggest creation of an interactive visu1ization. This interactive model will develop various composite components, such as the flow of signs and the flow of technologies, in more detail. It can also represent the interconnections between flow composites. Such an Internet visualization will be made with Internet technology. It will be accessible via the Internet. The visualization will be an interface ecosystem representation of an interface ecosystem, that is made from and bound in the same interface ecosystem. Strange loops proliferate. Theory and practice meet in interface ecology. This is an extreme example of a typical phenomenon.

3.8. metadiscipline [interlude 3]

Meta means change of order; it means after or behind; dealing with underlying, or more fundamental matters. [Oxford University Press: 1992] Meta is a means for trying to get a handle on levels that emerge through recursive calls. Meta gets slippery in strange loops. Referential levels can be formed, yet they may double back, circling. Godel proved that meta-mathematics cannot really be separated from mathematics; still, his proof is considered meta-mathematical.

There are several bases by which interface ecology claims to function as a metadiscipline. The first is more or less tautological. Interface ecology defines itself as an inquiry into the dynamic interactions between disciplines, among other systems of representation. Interface ecology's charter includes generating, as well as analyzing, interdisciplinary hybrids. It explores new combinations of disciplines. It deals with the underlying structure of disciplines.

Metadiscipline can be demonstrated, as well as directly claimed, through recursion analysis. This derivation is based on the establishment of a strange loop of disciplinary formations. From the start, I've moved back and forth between directly exploring interface phenomena, and developing a process for working with them. I've used the same means and mechanisms for describing each. The processes are congruent; at the same time, this constitutes a recursive convolution. The tangle in the referential hierarchy emanates from the principle of interpretation. The role of the ecologizer in the process of analysis cannot be passive. It is inherently generative. As the ethnographic text is, itself, an artifact, so all thick description involves thick creation. Doing interface ecology with either an analytic or generative orientation, is always creating material to which interface ecology principles can be further applied. Through ecologizing, a frame of reference, and thus an interface is created. From that moment, forward, our position as ecologizers is on the same level as that of our subjects. And so we are bound in an infinite recursive cascade of self-reference.

Look back to the original axiom, equal value, which was elevated to a theorem, based on the inherent dynamic power of meshworks. If this is an equal value system, there never was a hierarchy at all. Equal value sits at the base of a tangled referential chain. The underlying basis of the self-referential convolution is that interface ecology, itself, is a system of representation. It is a system of representation describing the formations of, structures of, and flows among systems of representation. It is a discipline that investigates and develops disciplinary formations. Therefore, interface ecology forms a metadiscipline; that is, it refers not only to the relationships between disciplines, but also, by nature (incessantly), to itself, and its relationships to those other disciplines, in the process. The results of interface ecology expect to effect their subjects, and so become them, recursively. The subjects of interface ecology, and the methods, cannot be separated.

The study of the dynamic interactions between systems of representation engages disciplines. It produces media representations. It reflects culture in its processes, as well as its subjects, and creates knowledge artifacts which are the essential cultural forms of the information age. Thus, this study, which I call *interface ecology*, is multi-dimensionally self-referential. Therefore, as Equation 3.1 is established (See

Section 3.4.5.), so, too, the metadisciplinary nature of the investigation of interfaces is likewise established. The ecological investigation of interfaces forms a metadiscipline.

As interface ecology examines its own recursive structure, as a metadiscipline, it also investigates its position among other disciplines. The structure of knowledge is rhizomatic, multibranching, full of associative links. Disciplines, meanwhile, are hybrid forms. Research environments in academia, even more than in corporations, tend to function as meshworks, because, at least until recently, and even still, universities are less demanding about controlling ownership of ideas than other corporations. Publishing, that is, the determination of what becomes generally accepted, on the other hand, is an inherently bureaucratic process. So are standardizing curricula and establishing canons of great works. Knowledge in disciplines becomes codified. Disciplines control the hierarchical form of accepted knowledge. While this provides focus, it also fetters. Under this system, it is difficult to create and find acceptance for knowledge that crosses the boundaries of disciplines. But such knowledge is crucial. Processes of combination create the dynamic potential for emergence. Interface ecosystems cross disciplinary boundaries indiscriminately in the scope of their actual dynamics. To investigate these phenomena, interface ecology combines disciplines equivocally. The equivocal combination of disciplines maximizes the flow of ideas.

Interface ecology encounters resistance from the hierarchies of disciplines, exactly because of these unauthorized transgressions. Bureaucracies are inherently inertial and territorial. They resist the new flows of change. They dwell in the familiar. A discipline is a urinal, like the one Duchamp exhibited. It is an information age readymade consisting of knowledge. To practice collage is to combine found objects of whatever form to create a new object. When disciplines are collaged, preinventive structures with preinventive properties of ambiguity and incongruity result. These precursors of emergence can lead to creative experiences. They motivate translation. They are catalysts which allow aggregates of disciplines to become self-organizing, self-sustaining meshworks. They are the tricksters of the border zones. They emerge through the transgression of boundaries.

An equivocal meshwork of disciplines may be perceived as an anathema by the departmental bureaucracies of universities and corporations. In any particular evaluative context (for example, in response to this work), individuals are likely to complain about being excluded by references to sources with which they are unfamiliar, and by the inevitable absence of some which they know well. They may also find too much explanation of some topics, or be put off by strange combinations of the familiar and the unfamiliar. Interface ecology does not fit within the hierarchy of any pre-existing discipline. This may threaten some and liberate others.

Arp called Dada, "a protest against the rationalization of man." [Museum of Modern Art 1958: 3] Interface ecology continues that protest, even as it also comfortably includes rational methods among its tools. Irreverence, the notion that nothing is sacred, that everything can be questioned, and made fun of, is a means for sustaining the circulation of ideas. As *Fountain* treated the art exhibition with irreverence, even at it began a new era of art; so, the notion of 'discipline as urinal' treats our knowledge institutions irreverently, just as it seeks to develop them.. The irreverence of *Fountain* and other Dada works played a key role in the formation of postmodern theory and practice; irreverence plays a similar role in interface ecology: to catalyze ongoing circulation amidst meshworks of systems of representation.

Chapter 4

Model

A model is a representation of structure, something that accurately resembles something else, a likeness or image. [Oxford University Press: 1992] A working model is one in which that resemblance is functional, in accord with the structure's underlying principles. It demonstrates them. *CollageMachine* is a model of interface ecology, inasmuch as its development process and workings represent ecosystem structure. More especially, *CollageMachine* is a model of interface ecology because the development of the artifact has profoundly influenced the development of the theory. This codevelopment effects ongoing change and evolution. Even as theory guides practice, interface ecology opens the door for practice to feed back to theory. This bi-directional flow creates a strange loop. Such non-linear flow relationships are characteristic of the ecosystem form. It is through this strange loop that a working model is established.

CollageMachine is an instance of an interface ecosystem. This interactive artifact has been developed through an equal value blending of disciplines. Computer science, music composition, art history, and cognitive science are among the constituents. Through practice of the generative mode of interface ecology, what was initially a fuzzy concept for *CollageMachine* – to compose for the World Wide Web – took clear and definite form. This concept drives the development process. The analytic mode concurrently develops a sense of *CollageMachine*'s historical/economic/semiotic context in the Internet. Sense of context, in turn, influences the concept. Design develops not as a dependent result, but as another back and forth component of the bi-directional feedback loop. As the design has been shaped by the context, which is perpetually in flux, so it also intends to effect that context.

The current version of the artifact is available through the web as a tool for browsing. Initial usability tests have been conducted with regard to this particular usage scenario. They have also influenced the design and have fed back to the concept. Other particular usage scenarios are also imagined. Some are already underway.

4.1. models

4.1.1. concept – context – design

The triangular concept – context – design loop is a new model for interactive artifact development. Other iterative design models [Rheinfrank 1992, Lewis and Rieman 1994, Suchman 1995] are driven by the tasks or activities of real users in actual usage scenarios. As compared to waterfall development models, which are linear, and don't take into account the need to get feedback and, potentially, to alter any aspect of a design, those iterative models are flexible and fluid. They adapt design to real world conditions. Part of what makes those iterative models effective is that, when executed fully, they conduct ethnographic investigation into the situations of users. The circumstances and resulting perspective of the user, in her/his role as "the other", can be inherently difficult for developers to comprehend. Steps towards bridging this cultural gap serve to align developers' understanding of the users' actual experience. Thick description informs thick

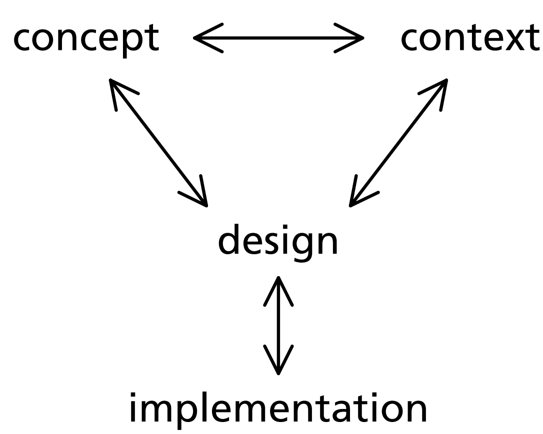

Figure 4.1 The triangular concept – context – design bi-directional feedback loop, a model for interactive artifact development.

creation. Gulfs of experience and execution are bridged. The better they understand users' actual experiences, the more able developers are to meet their needs. These iterative design practices work well when the goals for an artifact, and the underlying values, are clear. They are sufficient for incremental advances in interaction design.

A process of iterative design based on the present activities of a user population does not, in itself, offer a method for the creation of interactive artifacts that are more fundamentally transformative. How can we conceive new activities with interactive artifacts? The generative mode of interface ecology practice requires a broader, conceptually based approach. The goals of such an approach are to support the creation of work that redefines the nature of how people think about interactive artifacts, and/or how people express themselves through interaction. This approach augments activity-based iterative design methods.

Prior iterative design models have taken necessary steps to add dimension to the process of human computer interaction development; however, they still lack a big picture view. While arriving at one or more well-defined usage scenarios will always enrich a development process, such scenarios are not always a good starting point. That approach assumes that the activities of a certain set of users are relatively entrenched. Thus, in those scenarios, thorough understanding of what the users are doing can provide a complete basis for how technology – in the form of an interactive artifact – can make their jobs easier.

In fact, the greatest advances in what people call ‘interactive technology” have emanated from a different process. For example, consider hypermedia. Hypermedia is perhaps the most significant media technology in the history of civilization to be introduced since the printing press. The basic concept of hypermedia was conceived by Vanevar Bush as The Memex during the 1940’s. Ted Nelson[1] refined the concept and concretized details during the eighties. Tim Berners-Lee defined HTML. Marc Andreessen built the first browsers that were sufficiently powerful and usable to attract a mass of users. This coincided with the availability of sufficiently powerful personal computers and network bandwidth at a sufficiently low price point to entice the market. Usability studies did not play an essential role in any of these steps. Another example, the personal computer, has mixed origins with regards to these models. The Xerox Star was the progenitor of the modern PC. The role of iterative design and usability testing in the development of the Star “desktop” is well-chronicled and much celebrated [Winograd 1996]. The resulting system of overlapping windows, with the “desktop metaphor”, forms the basis of the graphical user interface for modern PCs. However, the Star desktop project was initiated as a result of Alan Kay’s “personal computing” concept [Kay 1993] In fact, the development of the first PC at Xerox is an instance of the proposed triangular model, because it began with a concept, and later, was refined through usability-oriented iterative design. In fact, the failure of the Star and its sister at Xerox, the Alto, can be linked to the failure of the developers to respond sufficiently to their context. The commercial failure of those products was a matter as much of their poor performance, as their high price

[1] Nelson, it happens, does not like the Web as an implementation of hypermedia.

(around $40,000), but. Microprocessors were not available at that time that could execute the Smalltalk language fast enough. Despite its conceptual elegance, if the developers had abandoned Smalltalk and recoded their implementation in C – that is, if they had done more to take their broader context into account – the details of the history of the industry might be quite different.

The concept – context – design loop is a model for fundamental research into human computer interaction, and for interactive art. The model's equal value blending of scientific and artistic methods illustrates the critical need for the ecosystem approach to interface development. Because *people* use computational artifacts, technological advance hinges on creative and cultural factors. Computer science cannot escape from the unboundedness of the "what goes on outside the computer" Pandora's box that Newell and Simon opened out of necessity.

The primary components in the triangular model are threefold. They are connected symmetrically. And yet, they are not all equal. The triangle starts in the upper left-hand corner. The process begins with concept. This is the point of origin, the inception. I always tell my students, "When you have a clear concept, you are ready to begin development." The origin of concept is internal. It is meditative. Concept emanates from desire. Concept is related to vision. The creator has a picture in her/his head. This is a beginning.

Context comes next in this model. Context can be considered on many levels. A broad sense of context, which takes into account many possibilities, and many underlying ecosystem relationships, enables the deepest possible impact. In the case of *CollageMachine*, I considered the context of the Web, and browsing, most broadly. I did not begin with real users or a real usage scenario. I was content to let concepts and instances of such scenarios develop along with the artifact.

One contextual issue for me, conceptually, was the rise of hierarchy in the World Wide Web. Nelson's critique of Web technology is that it lacks the inherent mechanism for hyperlinked annotation that he envisioned. In his vision of hypertext, everyone is an author.[2] The low-level infrastructure enables one author to respond to another.. Their content can be fluidly linked together, automatically. Because it constitutes content as an ongoing, multivocal conversation, such an authoring structure is strongly meshwork, and so can be expected to sustain the powerful meshwork dynamics that support ongoing initiative towards invention. The emerging environment regarding intellectual property on the Web, as evidenced by enforcement of the Millennium Copyright Act, discourages the creation of hybrid content forms based on collage. An example is the judicial restraining order against distribution of the DeCss program that allows digital video disks (DVDs) to be copied. This prevents digital access to that content even by individuals who have licensed the copyright by purchasing the DVD. Given that collage is the fundamental postmodern method for creating new work, this is a great hindrance to innovation. The largest media publishers are the supporters of these legal initiatives that constitute a primary anti-meshwork power.

[2] His vision is very text oriented. I would like to see people act as interaction designers, as well as authors. The two skills are integrated in the creation of Web content.

Web technology, while it lacks the inherent capability of fluid annotation, and in spite of the legal maneuverings of the publishers, still possesses meshwork attributes. There is the core, peer to peer TCP/IP networking technology, and its contrast with one to many publishing. HTML, the language of Web pages, is not so difficult, conceptually to understand and author. The technology of incredibly powerful personal computers is relatively inexpensive. Everyday PCs (under $1000) are quite sufficient for web authoring and serving. Even reliable wide bandwidth, which is necessary for effective Web serving, can be purchased at the time of this writing, at least in some parts of the U.S., for around $50 per month.

The meshwork attributes of Web technology are not sufficient to combat hierarchical tendencies in the Web's development. Creating sophisticated Web content is not so easy. Even beyond the restrictions that digital copyright enforcement imposes, access to much critical knowledge is structured normally, without legal barriers, in a way that reinforces prevailing distributions of wealth and power. In addition, as bandwidth increases, convergence with streaming media such as video and audio increase barriers to entry. There are also social issues, regarding who is motivated to do what kinds of creation in our society. The form of the technology to which the mass audience is directly exposed, and their perceptions of the medium, effect their response. This sense, as developed in Chapter 3, is a matter of sign values. The web is distributed, in default form, as browsers that automatically go to some default portal on startup. Most users do not change these settings.

The conflicting factors towards meshwork, on the one hand, and hierarchy, on the other, do not resolve to a clear balance of power regarding the organizational structure of the net. However, if my browsing habits are any bellwether, hierarchy is winning. It is always dangerous to pick oneself as a sample. However, in this case, I am relatively aware of what's happening on the Web. I am relatively motivated to seek out interesting content on the fringes. What I can report, is that more of my time online is spent browsing content created by capital-intensive publishers, than is spent browsing content from more meshwork sources.

There is an irony in offering *CollageMachine* as an artifact that gives users more control over their browsing experiences. A typical browser acts only in response to the user. It only goes where you tell it to go. As an agent, on the other hand, *CollageMachine* takes control of the browsing experience. It follows hyperlinks and presents media elements on its own volition.

However, while *CollageMachine* takes more control of navigation, it lets the user rearrange the display. A typical browser presents the Web precisely, according to the specifications of Web designers. As the content viewed by most of the people, most of the time, is authored by a relatively small group of creators, representing a relatively small number of powerful publishers, this effects hierarchy. *CollageMachine* puts the media elements it finds into an authoring space, like a design program. It puts the elements into the user's hands, instead of simply presenting them according to designers' plans. This gives the user a new control of browsing. In addition, *CollageMachine*, through its web crawling, will bring the user to unplanned destinations. Through this function, the artifact opens the space of Web destinations that the user sees. Through the “Goto Web Page” tool, the user can connect this collage browsing experience with her/his conventional browsing experience. In the current implementation s/he can bookmark newly discovered sites of interest after using this tool, and visit them again later. The artifact’s success in acting on behalf of the user, in the end, might be measured in terms of how well it does in choosing media elements and web sites, and making layout decisions. This success depends on the effectiveness of the agent model in actually representing the user’s interests. By presenting Web content in an authoring space, and laying content out with regards to the user’s interest’s, *CollageMachine* opens the browsing experience. It also reduces the role of a small set of content publishers in determining that experience. Thus, it can serve to subvert hierarchical energies and give the Web more meshwork character. That is, part of the concept for *CollageMachine* is not only to be part of a prevailing context, but to play a role, to influence and transform that context.

Through design, the actual artifact takes shape. By design, I mean all manner of plans, strategies and tactics involved in realizing the concept in the situation of the context. Design is a situated [Suchman 1987] conversation with materials [Winograd 1996]. Design utilizes the properties of the materials [Papenek 1995] – be they interactive devices, cameras, microphones, programming languages, paints, or fabrics – and of prevailing as well as imagined significant behaviors. Design involves creating form for the concept. It builds and accounts for associated relationships. I construe design most broadly, including both the artifact’s situation – that is, relationships with its context – and internals – that is, the means and manner of its formation from materials. Further, the distinctions between design and implementation – the leg at the base of the triangle – are fuzzy ones. There is a continuum which results both from the nature of the creative process, and from the back and forth flow of feedback and revision. Design and implementation are more connected than separated. This concrete making includes all appropriate science and engineering. Interaction design, graphic design, performance, and sculpture are there. Accounting for cognitive factors is part of it. The design and analysis of languages – including semantics and translators – as well as data structures and algorithms – including complexity analysis – is involved. Likewise, included are object oriented designs, which structure software to manage complexity.

As the development process proceeds down the bottom leg of the feedback triangle, towards final implementation, concrete usage scenarios develop. With *CollageMachine*, this transition was not planned. A demo version of the artifact took form. People started to see it, and to respond. I started to see how people would interact with what I was building. In response, I was able to think more concretely about both about how I wanted the artifact to work, and how people can use it. Each of these scenarios is associated with a particular environment. As these use contexts are specified, they become the appropriate targets for activity analysis, ethnographic inquiry, and usability studies. The current implementation of the artifact is as a tool that is available as part of the Interface Ecology Web [Kerne 1997]. It offers streaming collage browsing as a free service for users. This usage context is not particularly well developed. Section 4.6 describes various more particular usage scenarios, some of which are already under development, and some of which are hypothetical.

4.1.2. the creative cognition of collage reapplied

As interface development is a creative process, so it makes sense to consider in terms of the Geneplore model, and its application to collage. The development of concept is the essence of the generate stage. Generate, like concept formation, is an internal process. While generation proceeds ultimately in response to the outside world, in a feedback loop, it essentially consists of the artist's internally motivated process of reflection and creation. The initiation phase of material design (see below) is similar. Consideration of context is an exploratory activity. Whether it is based on a broader sense of history and culture, or a particular usability scenario, context motivates the interpretation of concept and design preinventive structures in light of real world factors. Incorporation of such factors happens in the feedback loop which returns to generate. (See Figure 2.4 and 2.5.) Emergence occurs as part of that generation in response, and during interpretation, when it becomes clear that a generated design locks in with interpreted conditions. This model can be extended to describe my CollageMachine development process. In this application, the practices of the collage artist and the human computer interaction practitioner meet. This is a conceptual, processual interface, treated as an ecosystem. The results can be applied generally to processes of hci development.

In this creative cognition of human computer interaction development model, conception is an internal process of "generation", and interpretation is the interchange that involves getting feedback – the world's responses to generated

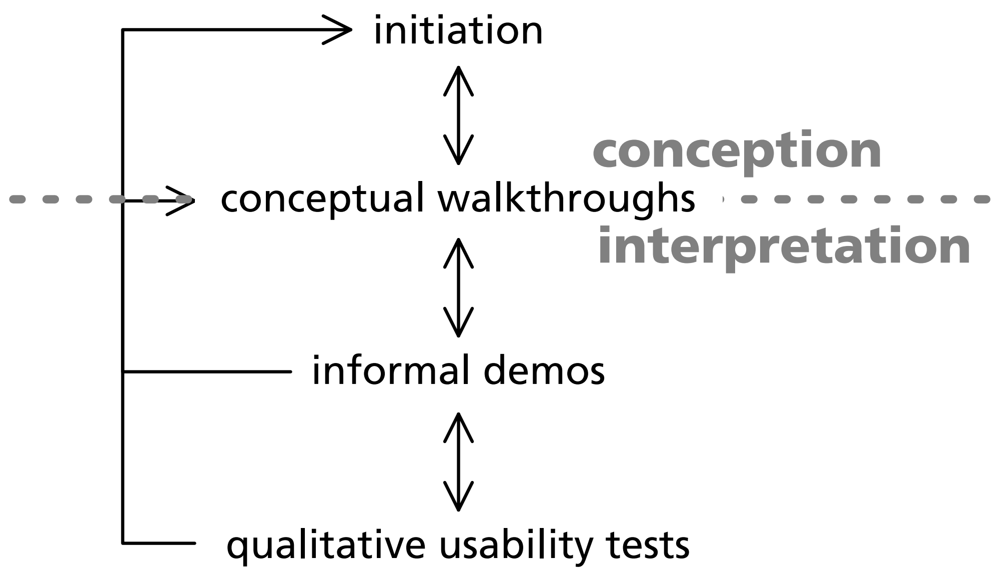

Figure 4.2 Two modes of cognitive circulation in human computer interaction development, and the four interconnected phases of which they consist.

artifact forms. Feedback flows through connecting loop linkages to get incorporated. I substitute the term *interchange* for *exploration*, because the latter comes with the unilateral connotations of imperialism. Interchange, meanwhile, connotes a more symbiotic, multivocal flow. The developer doesn't just act upon the world, s/he works *with* it. Taking an ecosystem view, Geneplore circulates cognitive components.

4.1.3. cognitive circulation in hci development

The triangular model addresses four kinds of processes that developers engage in. Concept is self-motivated. Concept directs the conversation with materials, the definition of context, and its traversal. Context involves the world, both as a source of ideas and of constraints. Design and implementation involve materials and processes. As it gives form to concept, design straddles generate and explore. While the flow of development starts with concept, and initially moves through consideration of context, before deep involvement in design, it circulates bi-directionally. Response to experience in any node can feed back to any other. This overall flow keeps things open and makes them responsive. Creative, ethnographic, scientific, and engineering aspects of development are composed ecologically. Equivocal relationships develop meshwork.

As a project moves from inception to final implementation, development shifts from more internal, isolated processes, to more external ones. Generate gives way to interchange. The triangular model does not address the practice of this shift. Human computer interaction development is an overlapping series of cognitive circulations. Even while there are no one-way arrows in this iterative model, the artifact moves from inception to completion. The circulation process progresses through modes and phases. For *CollageMachine*, these phases of generation and interchange are: initiation, conceptual walkthroughs, informal testing, and qualitative usability testing. They are arranged iteratively in Figure 4.2. Each of these four phases is a component of one or two modes. The first mode, conception, refers to the part of development in which developers work in isolation, in labs and studios, or more personal settings. During conception, circulation may be primarily internal. Both imaginations and users/audience may play key roles. Mental models are generated and compared. Conception includes the initiation and conceptual walkthrough phases. The second mode, interpretation, is about getting feedback. It includes conceptual walkthroughs, again, as well as informal demos and qualitative usability tests. Cognitive circulation is not limited to these four phases. Other accepted human computer interaction design practices, such as cognitive walkthroughs, heuristic evaluations, and quantitative usability tests also constitute interpretive mode phases of development. Their exclusion from this process so far is a matter of circumstances.

The earliest cognitive circulations are meditative dialogues with self. When a project is collaborative, "self" can include any participants. Initiation, the first phase of development, refers first to the initial development of concept, and then likewise to the initial development of the artifact form. Until the concept takes initial form, context is unbounded. Without form, feedback is limited. As concept takes shape, context becomes more well-defined. The interchange between them can become focused. When this definition reaches a certain threshold, development of the artifact begins. Initiation is repeated. Concept, an internally conceived blueprint, is the primary guide. Developers form a first version of the artifact, using "materials".

Conceptual walkthroughs are the second phase of this interface artifact development process. Conceptual walkthroughs straddle the border between conception and interpretation. I have coined the term by translating the common human computer interaction design practice of conducting *cognitive walkthroughs* to this development process which emanates from concept. Cognitive walkthroughs are a task-centered interface design method for evaluating a design without users [Lewis and Rieman 1994]. This approach begins with a "task analysis" which identifies the essential roles that users play in their work, and representative tasks that they undertake. In a cognitive walkthrough, developers act as if they are the users in their roles. They perform the representative tasks, using the interactive artifact. They observe gulfs between the needs of the user performing her/his task and the actual function of the artifact. Afterwards, they iteratively redesign the artifact to bridge such gulfs.

Conceptual walkthroughs evaluate an interactive artifact similarly, but with respect to its concept. The developer attempts to use the artifact as s/he imagined it would be used. S/he notes gulfs between the actual experience of using the artifact, and the conceptualized one. These perceived gulfs could be very general, or very specific. For example, with *CollageMachine*, the concept that the streaming collage session could be "steer-able" emerged early on. That is, I wanted the user to feel like s/he could maneuver the collage, so that it's retrieval of media elements and documents would go in a desired "direction". The concept was part of the project in a vague form for years, before I actually designed and built the current architecture of an agent model based on floating point weights. That is a broad notion of concept, which can be evaluated through conceptual walkthrough. More specific concepts can also be evaluated. The current agent model is far from perfect. When the user clicks on a media element with the "I like" tool, I want the user to experience the introduction of similar material into the evolving collage. Evaluating the performance of artifact in a such a situation can involve very detailed analysis of the state of the agent model. What elements are in the grid, and the available collections? What are the values of their attributes? How did clicking change these values? Did it do what I meant or there a bug in propagation? Two weeks ago I was working on new features for *JumboScope* that support model propagation from the applet to a Web server (See Section 4.4 below.). I had to look at exactly what was being sent. In the process, I noticed a bug in the model code that was probably two years old. Identifying and fixing the bug is a very specific, detail-oriented undertaking. This process of conceptual walkthrough both identified the bug, and its resolution. The result is a more steer-able user experience.

Developing *CollageMachine*'s agent model and visualization involves *tuning* the values of constants. By and large, these constant values are very application context specific. I futz with them almost every time I work on inside *CollageMachine* development. I don't have any final results to report on them. They remain an ongoing work in process. Yet, their values, as a complete ensemble, are critical to the application's function. It is possible that at some point I may decide that it is desirable to subject certain parameter value choices to usability testing. So far, conceptual walkthroughs are sufficient. I work like this: first, I somehow set the values. Next, I run *CollageMachine*, and play with it. I examine the results. I correspond what I am seeing with the values and equations that I have set, as well as with the concept. Here, by the concept, I mean my imagined sense of how it should work, the feel I am looking for. I iterate, modifying the parameters, running, and inspecting again. This is the process I call tuning. Tuning constant value parameters, as such, and even establishing the equations through which parameters influence each other, is achieved through conceptual walkthroughs.

Parameter tuning as part of conceptual walkthroughs arises in other fields. Some years ago, I did quite a bit of work with a Serge modular audio synthesizer. This device consisted of a large number of sound and control voltage processing and generating modules. Control voltages are signals that vary much more slowly than sound waves, and yet which are useful in shaping their parameters. One typical control voltage is the amplitude envelope of a sound signal, which is obtained from an extreme low pass filter called an envelope follower. Working with the Serge involved created complex “patches” which connected modules in elaborate circuits. Feedback was a large part of this. All the inputs and outputs of Serge modules have knobs associated with them. In most cases, these knobs multiply or divide the signal by a constant value. One critical phase of building a Serge circuit involves tuning these constant values.

Another audio example of tuning doesn’t directly involve electronic factors. In audio engineering, the creative process starts the artists and instruments you want to record, and some sense of the sound you are looking for. The first key determining components are the selection of room and microphone(s). Once these are determined, placement of the musician(s) in the room, and of the microphones, relative both to the room and to the sound maker(s), is critical. A wide range of sounds will be available, even after the room and microphone have been chosen, based solely on placement. This is because frequency response characteristics will vary enormously. These seemingly simple placement choices are equivalent to turning knobs or tuning digital constants in software. These tuning decisions shape the results essentially. Tuning is accomplished through conceptual walkthroughs, in which the actual state of the system is compared with the imagined, desired result, that is, the concept.

Following conceptual walkthroughs, informal demos are another useful method for gathering feedback. In an informal demo, a developer sits with another person and shows her/him the artifact. Perhaps the other gets to hold the mouse for a while;

perhaps not. In any event, the agency for operating the artifact is at best distributed between the developer and the other.

Usability testing gets the developer out of control of the artifact during the evaluation process. The other is now definitively a user. The ability of most usability tests to demonstrate the results of actual use is limited inasmuch as typical testing scenarios are contrived. They are also biased towards the experiences of novice users, unless actual long term users are recruited. Nonetheless, such tests are extremely valuable, because they concretely show the developer what an actual user experiences. For the developer, this can be painfully humbling. Section 4.4 begins by describing the ethnographically oriented usability tests I would like to conduct. It then details the tests actually conducted, and the results.

4.2. conceptual walkthroughs and informal demos

Many crucial design issues have been worked out through conceptual walkthroughs and informal demos. In some cases, these interpretive phases of development have uncovered fundamental incompatibilities between context and concept, themselves. The result is conceptual evolution, followed by design revision. In others, the scope of discrepancies was limited. In these cases, it was only necessary to resolve the design to make it more compatible. Concept and context remained unchanged.

4.2.1. interactive semantics of streaming visualization

Norman's immensely useful concept of mapping relates the appearance of an interactive control with its function. A mapping relates "what you want to do with that appears to be possible." [Norman 1988: 5] *Mapping* is sufficient nomenclature inasmuch as function is obvious. Norman's beautiful case studies of door handles illustrate this. What is in doubt, in weak designs, is what you do to open a door. That what you want to do is to open the door, is never a matter of question.

Mapping needs to be extended for situations which provide new functions, and new paradigms. In these situations, interface artifact forms need to have a wider effect. They need to communicate meaning and function together. *Interactive semantics*, then, broadens mappings to refer to the overall communication of meaning by interactive elements, through affordances.

A combination of conceptual walkthroughs and informal demos revealed that the form of streaming visualization affords particular interactive semantics. Most information visualizers use dynamic display only to effect transitions, in response to interaction.[3] [Perlin and Fox 1993, Bederson and Hollan 1994, Lamping et al 1995]. For example, in Pad, transitions of zooming in and out are animated. Like other interactive artifacts, those visualizers do nothing to make use of presentation environment resources – such as a desktop PC or a kiosk – during the considerable periods of time when a user is not interacting. I often ask audiences what a typical e-commerce Web site does if you go to its home page, and then don't click on any hyperlinks. The answer is, "Nothing." The resources of the catalog, as well as the PC, are wasted.

Through development of *CollageMachine* concepts, the form of streaming visualization emerged. Streaming visualization is characterized by on-going, continuous dynamic changes to the display. Concurrent interaction on demand can be initiated at any moment. The combination of streaming and interactivity is unusual both for the user, and for the developer. Except in some simulation games, like Quake, usually when content is changing, it is not possible to interact at the same time. Most applications move to scenes, and then pause. Once those transitions are complete, the scene is static until the user interacts. In contrast, in *CollageMachine*, the scene seems to be continuously in flux, except in response to the user's intentional stop command. The characteristic of continuous streaming creates certain interaction design requirements, and certain implementation issues. These, in turn, determine corresponding design principles and interactive semantics.

[3] Two exceptions to this are Netomat [Wisniewski 1999], and Thinkmap [Plumb Design: 2001]. Of these, in the latter, animation in the absence of user interaction is minimal. Therefore, the issues raised here hardly apply.

Conceptual walkthroughs and informal demos demonstrated that if the collage element under the cursor changes – that is, if it is automatically removed from the Collage Visualization Grid, or if a new element covers it up – it causes a problem. In the case that the user is interested in that element, the experience is especially disconcerting. This is especially true when the user is actively involved in interaction. S/he might be just about to click on an element, only to have it suddenly disappear. While conducting informal demos, I observed that if s/he is ready to interact, and the groundwork for that interaction suddenly shifts, the result is cognitive dissonance. The user is frustrated.

Thus, during streaming visualization, the user needs some quiescent space in the vicinity of the cursor. The resulting design principle is that changes to this quiescent region should only be initiated by the user's direct manipulation actions. The corresponding interactive semantics are that the program, as a proactive agent, will consider that space off limits. *CollageMachine* effects this principle by removing the grid region associated with the collage element that is on top and under the cursor (whenever there is one – except when the grid is relatively empty) from the set of those considered as placement locations for new elements. While competition for attention is not eliminated, this design ameliorates the problem. A more extreme, and perhaps even better solution, would be to additionally impose a gradient that reduces weights of elements in some region around the cursor. Thus, real estate near the cursor would be a less likely destination for new elements. The problem with implementing this that come from the aforementioned concurrency of interaction and streaming. The data structure that is used for calculating weighted random selection of candidate grid regions for placement of new collage elements must be locked during that calculation. The duration of that locking is significant relative to the time that it takes the user to move the mouse. Thus, the cursor might not be in the same place as it was at the beginning of such a gradient weighting calculation, by the time that it completes. Future usability testing can compare users' sense of satisfaction with different extents for the quiescent zone. Quantitative testing that compares factors such as frequency of blinking given different extents might also provide interesting results.

While conducting conceptual walkthroughs, when I first implemented the feature that enables the user to drag elements to rearrange the collage, I realized that they, too require particular interactive semantics for streaming visualization. In the case where the user is dragging a collage element, s/he is directly making rapid changes to the visualization. These changes may be carried out in relation to any area of the screen. There is no way for the program to know where s/he will want to put the element, at the end of the drag action. Indeed, users may hesitate and change their mind during dragging. The ground the user is dragging above should not be changed out from under her/him while dragging is in progress. Therefore, the interactive semantics for dragging in *CollageMachine* constitute a transparent, automatic stop operation at the start of a drag event, and a corresponding restart when the user finishes dragging. This enables the user to design the collage without the program's intervention during these periods.

These interactive semantics for streaming visualization – the quiescent region around the cursor, and the cessation of collage updating during drag events –

become transparent aspects of what the interactive artifact is to the user. If these semantics are violated, users will feel disrupted. At the same time, users do not have to be aware of these semantics in order for them to be effective. Advanced users who notice their operation might exploit them: for example, one way to guarantee that part of the visualization will not change is to position the cursor over a particular element. Indeed, if one is considering interacting with an element, this is the only way short of stopping the session to guarantee that the element will be there in some future moment. These particular interactive semantics apply generally to any artifact of streaming visualization. There are other interactive semantics particular to *CollageMachine*.

4.2.2. color harmony and visualization

One of my earliest concepts for *CollageMachine* was to experiment with using Itten's principles of color contrast and harmony in information visualization.[Itten 1970] These principles include light-dark contrasts, cold-warm contrasts, contrasts of saturation, and contrasts of hue based on complementary colors. Early versions of *CollageMachine* played with color contrasts in each collage element, independently. I used Perlin's bias and gain functions to shape the random distribution of the hue, saturation and value parameters that define a color. I developed heuristics to choose text and background colors that contrasted sufficiently to insure readability. This algorithm takes nonlinearities between our perception and the HSV color space into account. While I enjoyed playing with this, some web site authors complained about the complete lack of role that their design designs played in *CollageMachine* visualizations.

In response to these complaints, and also because I wanted to use color to create coherence in the visualization, I adopted a new approach to choosing the colors of collage elements. In the new scheme, colors are based on those set in the source Web page. That is, each element's background color[4] is derived from the page's background color. The background hue is the same as that of the page's background.[5] Saturation and value are varied, in a fairly tight band around the originals. The same hue and saturation are used for all the elements in a single page. This results in some variance. Colors are close enough that elements from the same site look similar. Those from a single page are colored identically. If the element is a text element, the text color is similarly derived. This provides the user with visual clues about the relatedness of the origins of collage elements.

4.2.3. it's mine. don't cover it up.

In the first versions of *CollageMachine*, selection and placement decisions were entirely random. Seeding determined a session's point of initiation, but after that, the collage could crawl anywhere on the web. Through informal demos, I made several observations. With appropriate seeding, users would find material of interest, and derive some pleasure from seeing it in the collage. However, if those elements were covered up or removed, they were disturbed. This was particularly

[4] This applies to text elements, and to GIF images that with transparent backgrounds. Other images are displayed in *CollageMachine*, as in typical Web pages, with their inherent composition of foreground and background colors.

[5] This is actually only true in case that background has a hue. For colors with no saturation, that is, white, black, and grays, hue is indeterminate in the HSV color model. When such an element is encountered, in order to allow for variation in saturation to be perceptible, *CollageMachine* assigns a random hue. By analogy with the program's behavior for cases in which hues derive deterministically from the Web page, the same random hue is used for all pages in a single site. The random hue algorithm borrows from the previous color selection algorithm.

pronounced in cases where the user had used the interactive tools to pick up or move the element.

A series of features resulted from this need for users to derive a sense of domain, of control, over the collage elements with which they interact. Development of an agent model, and incorporation of this model into layout decisions, has become fundamental to *CollageMachine*'s operation. This signature characteristic was not part of the original concept, except in the vague form of a sense of steer-ability for collage sessions. The Collage Visualization Grid, which allocates screen real estate dynamically, representing the weights of elements, is the result. While the first versions of the application employed a grid to produce visual polyrhythms (See Chapter 1), weights were not part of that grid's operations. Its complexity, in terms of implementation, and utility, for the user who possesses any interests at all, were limited. The current grid visualizes an emergent model of the user's interests in response to interaction. As I built it, I had a strong intuition that this would be a watershed feature for *CollageMachine*. Informal demos confirmed this. I observed that users responded with a different level of involvement.

The operation of the grid has been refined in response to ongoing interchange. During usability tests, a few users expressed an interest in having part of the screen for themselves. They could drag elements to this "docking area"; the space would be outside the bounds of *CollageMachine* dynamic layout. Rather than implement this feature directly, I have recently chosen to refine dynamic interaction semantics regarding elements the user has directly interacted with. Heuristics assign particularly low screen weights (high significance) to these elements. The result is that such elements are extremely unlikely to be covered up or removed. Thus, a docking area can be created dynamically, anywhere amidst the collage, by dragging elements together, instead of statically taking screen space which might not be used. The magnitude of this operation is much greater than that of the underlying significance model that is propagated to other media elements. Most generally, maintaining a tuple of attributes for each media element, and applying different metrics to this vector as part of different operations, has proven itself to be a power and essential paradigm for developing and applying the agent model. In other words, building the model, and interpreting the model are distinct, though related algorithmic processes. The value of multiple algorithmic interpretations is analogous to multivocality.

4.2.4. how random is the layout?

From the start, I was concerned that layout through the grid would look too orderly, that the feeling of open ended possibility that comes with indeterminacy would not be conveyed. I wanted a fuzzier feel. Therefore, early versions of *CollageMachine* added small random factors to placement coordinates, in order to rough up the layout. Later, I added the agent model and made the grid allocate space according to priority. This was a complex piece of code. As I was debugging it, I wanted to make it as simple as possible, so I didn't include the roughing up code. As I got the code working, I realized, through informal demos, that no one perceived the results as too orderly. Indeed, more order seemed to help them orient themselves. As part of the same debugging process, I painted the grid lines on the screen. Previously, they had not been visibly rendered, even though they were essential to the internal layout algorithm. I noticed that the lines also helped people orient themselves. Based on positive feedback in informal demos, I kept them in the background of the visualization.

4.2.5. size matters

CollageMachine is an approach to the fundamental situation that arises when one wants to browse or provide more media elements than can fit on the screen at one time. Thus, its operations are about making effective use of screen real estate. One visual design idea which evolved was the layout and placement of the control panel. Floating controls, in the manner of Adobe Photoshop and Illustrator, were not an option, because the Java 1.1 toolkit does not provide the necessary infrastructure. The first design, allocated a strip along the top of the screen, as wide as the display, for the control panel. During informal demos, several users complained about the waste of space. Johanna Herget and I designed the control panel of Figure 2.10 to remedy this.

The size assigned to each new collage element is another significant attribute of how screen real estate is allocated. Until quite recently, sizes were chosen randomly from a certain range, as if size didn't matter. As *CollageMachine* development has progressed, with regard to indeterminacy, I have become more and more interested in structure, and less interested in randomness. That is not to say that I have ever considered eliminating the use of indeterminacy. Only that it becomes more important for the interactive semantics of the visualization experience as a whole to make sense to the user. I want the experience to feel more responsive and less arbitrary.[6]

The complete randomness of the choice of the size of new elements bothered me for quite some time before I most recently got around to structuring that decision. This was entirely a result of conceptual development and walkthroughs. I would cringe internally about the entirely random way sizing worked as I watched collage sessions, especially when something unimportant appeared with fairly large size. No user or demo attendee ever complained about the way it worked. Also, I had been wanting to allow larger collage elements, because I thought they would look nice. Previously, the maximum horizontal dimension of a collage element was around one fifth of the *CollageMachine* window's width. Conceptually, I coupled opening this up with developing a smarter algorithm for choosing the size of the new element. The reason for this was that larger new elements will cover up more of older elements. I figured these large elements had better be something good to be worthy of covering so much up.

The resulting new sizing algorithm is adaptive. It uses something which resembles a logarithmic form of a moment of inertia, in order to decide the size for each new element. The screen weight of the new element is compared to the mean of the screen weights of all elements in the grid. The resulting size is based on a linear interpolation between the mean possible size and the most extreme possible size. The appropriate extreme is determined by whether the new element's weight is greater than or less than the mean. The extent of the interpolation is based on a

[6] I imagine Cage would really not agree with this aesthetic. So what?

proportional interpolation which positions the log of the new element's screen weight between the log of the average screen weight and the log of the most extreme screen weight.

4.3. usability testing

4.3.1. lofty ideas: ethnographic study of browsing and foraging

Interchange proceeds from conceptual walkthroughs and informal demos to usability tests. I have some lofty ideas about how to conduct usability tests. Referring back to my introductory conceptual sense about play and what actually constitutes browsing, foraging and surfing (See Section 1.4), I would like to conduct an ethnographic study of people's browsing habits in different situated contexts. Homes, libraries, cafes, schools of different levels, and workplaces will be comparatively assessed. This study will include introduction of *CollageMachine* and looking at people's responses to different aspects of it, as well to a structured set of different versions. Different approaches to history-enriched interest wear visualization treatments of collage elements are an example of a factor that can be varied in a controlled way with different users. Exposure of subjects to versions of the relatedness identification algorithm, deep within the agent model, could be varied similarly. The goals of these usability tests will include proving or denying differentiation of foraging habits, according to usage context. I wonder if different social and interactive activities might result in the same kinds of environments, depending on whether or not the users have access to and knowledge of *CollageMachine*. Could it change their browsing habits, and modes? Would any such effects occur in one kind of a social context, and not in others? Conversely, is interest in a playful tool, such as *CollageMachine*, differentiated or consistent across contexts? A study of this kind could unearth interesting data both about *CollageMachine*, and about browsing, itself. During the past cycle of research, I decided that this study was immediately out of scope. In the future, I will seek funds to support its undertaking.

4.3.2. actual activity-oriented process

The usability tests I have actually conducted were activity based. I recruited a pool of participants through NYU channels. All were somehow connected to the university. They were students, staff, and, in one case, the child of a staff member. I would have preferred a wider population spectrum; again, limited resources discouraged that level of exploration. The 13 participants ranged in age from 12 - 47. Gender was balanced. Aside from the one 12 year old (the daughter of a Ph.D. professor), all had at least a bachelors degree; more than half had a masters. That is to say, they were an overeducated bunch. They also were all interested somehow in the Internet and interactivity. I mention limits in the participants' population in this study especially because, through an ongoing process of surveying CHI literature, I observe that that insufficient attention is given to the makeup of sample space. Sample spaces define the scope of an experiment. Interaction researchers routinely draw broad conclusions from narrow data. While these studies often produce interesting results, the level of recognition generally awarded to those who conduct such user studies by "the CHI community", and the absence of rigorous standards for sample space design, are discrepant. As my statistics' teacher Charles Philip used to say, “Lies, damn lies, and statistics.” For what its worth, where there are strong numbers, I report percentages in analyzing the results of the tests. In other cases, I simply cite a few users, or some users. I frankly don’t thing the numbers matter in all situations. Using numbers to make results *seem* more valid does not strike me as good science.

However it reports statistics, any usability study is bound to produce at least some worthwhile feedback for interactive artifact developers. The feedback provided by making “the other” into users, who are bona fide at least to the extent that they are not being coached, was as humbling as it was informative. It takes a certain discipline to watch users struggle with your handiwork, and not intercede to help them.

The tests were conducted over a period of two subsequent days. Extensive changes to the HTML level interface were made between the starts of the first day, and the second day. I couldn’t bear to watch the same mistakes being made over and over.

Each session ran approximately one hour. In a some cases, the full battery of activities was not performed. This could result either from the user struggling to accomplish them, or more likely because interesting tangents arose, and I, as the administrator of the tests, allowed them to be pursued. The testing procedure included a questionnaire, which was administered in three phases. The questionnaire was implemented via a three-tier interactive technology. The subjects filled out forms in a web browser. A Java Servlet collected the data, and formatted it as XML, and output a separate flat file for each user for each phase.

I converted the Media Research Lab's black box theater space to a usability lab for the tests. Except for the periods of time when 719 Broadway roof repairs were loud, the space was well-suited for the occasion. I setup a video camera, and a microphone. I recorded video both from the camera, and directly from the monitor of the computer the subjects used. The same sound went to both tapes. I would have like to have synchronized the two decks to common video black burst and sent the same SMPTE timecode to both decks. This would enable automatic lockup in post production data analysis. However, I used the deck built-in to the camera to record its signal. This device lacked synchronization and timecode inputs. The common soundtrack can be used to achieve crude sync after the fact.

The sessions began with a short briefing. I mentioned that "*CollageMachine* gives you a new way to interact with the Internet," and that playing is part of using it. I did nothing to inform them about how the program works. They were asked first to examine the artifact, starting at the HTML *CollageMachine* home page, and to figure out what it does and how to use it. Most subjects jumped into using the artifact without reading the documentation.

After this introductory period, I asked them to perform a battery of activities. These activities came from two distinct sets. Those in the first were atomic and feature-oriented. They addressed using each tool or control in *CollageMachine*. Here is a list of the activities:

1) Delete elements you don't like.
2) Speed up or slow down the session.
3) Review the help screen.

4) Go to the web page associated with an element.
5) Lift elements you like that are partially covered.
6) Stop the session without ending it.
7) Tell *CollageMachine* you don't want any more elements like one already on the screen.
8) Continue the session.
9) Drag elements you like to be next to each other.
10) Tell *CollageMachine* you want more elements like one already on the screen.
    Make sure it brings more of them.
11) Identify elements that *CollageMachine* thinks you like.
12) Identify elements that *CollageMachine* thinks you don't like.
13) Tell the developers about something that's good or bad about how *CollageMachine* works.
14) Delete elements in order to influence what media will come into the collage.
15) End the session.

As you can see, some of these activities are very directly associated with the basic functionality of an affordance. For example, "(1) Delete elements you don't like," asks the user to exercise the I don't like tool. Some are a bit more abstract. They incorporate the artifact's experiential semantics. So for example, "(7) Tell *CollageMachine* you don't want any more elements like one already on the screen," actually asks the user to perform the same task as (1). However, this time, the phrasing requires a different level of cognition from the user. S/he must think in *CollageMachine*'s terms to realize that the artifact not only affords deletion of elements, it also constitutes such deletions as a form of training, as the basis for a model of likes and dislikes. In the end, those deletions are fuzzy commands about what to bring to the collage, and how to arrange it. Along with (5), (9), and (10), these modes of interaction form the basis through which *CollageMachine* enables the user to "steer" the collage session. Activities (7) and (10) are defined with a level of abstraction that incorporates *CollageMachine*'s experiential semantics. Indeed, taken as a whole, these atomic activities function suggestively regarding what *CollageMachine* does, and why. In one sense, they guided the user to consider various aspects of *CollageMachine*'s functionality. Through this guidance, they enabled a dialogue to occur about this functionality in a relatively short period of time. Given the overall novelty of the interactive streaming collage paradigm, and the limited scope of the usability study sessions, this guidance was beneficial.

After the feature-oriented activities had been completed the users were asked to engage in a few more open ended, abstract activities.[7] These are more generally related to browsing and foraging.

1) Use *CollageMachine* for a search.
2) Use *CollageMachine* to look at a favorite web site or sites.
3) Use *CollageMachine* to explore a popular mix.
4) Do you have any other ideas about how to use *CollageMachine*? Explore one.

Here are salient usability test results:

69%	learn what steering is and how to do it
93%	interest in the streaming collage paradigm
69%	struggle with tools – need clearer tool semantics
77%	ignore instructions
23%	trouble finding control panel in bottom right
30%	understand interest-wear history enriched collage element

[7] Note that while my requests for activities were structured in this way, some users got into the more abstract activities sooner, on their own volition, as part of doing a simpler one, or even as part of the initial, figure out how it works process. In keeping with the notion of supporting open-ended processes, I did not force the sessions into my structure.

4.3.4. conceptual confirmations / future work

Mostly, the issues discovered during usability testing have been less fundamental than those identified through conceptual walkthroughs. The conducted tests have served on the one hand to identify usability issues with skin-deep solutions. While the resolution of some of these usability issues has been more a matter of attention than of extreme undertaking, these issues are at least as important as deeper matters of concept and design. The tests demonstrate that the power of the underlying feature set only matters to the extent that people are able to use it. People respond fluidly to subtle cues. The sensitivity of an artifact in providing the cues that users need plays a critical role in their acceptance or rejection. Users respond to the interface ecosystem as a whole, more than they respond to isolated aspects. For visualization techniques and agents models to be successful, they must be wrapped in usable interaction design.

Usability tests did serve in several ways to validate the concept, including planned priorities for future work. Subjectively, 93% of users expressed interest in and attraction to the streaming collage paradigm. They liked having an agent fetch media for them. They liked the collage format. They liked the direct manipulation control afforded by the "I like/grab" tool, especially when they used it for dragging elements. They related to the playfulness of it. One said, "It is a lot of fun to use and it lends itself to web free association." Another offered, "I think that the program helps you find a good website to go to when you're stumped." Thus, *CollageMachine* was seen as a recommender system, even though it hardly has that functionality, so far.

In fact, recommender system functionality is critical. While users were pleased by the overall concept, they expressed interest in the agent functionality of *CollageMachine* with surprising articulation. “How does it decide what is related?” 85% wanted to know, and wanted it to work better. This is the province of the agent model, and its system of weights. As I have described in Chapter 2, the current version only works in terms of the Web’s structure of hyperlinks. It produces decent results with this approach, but not great ones. The users themselves suggested the other approaches already on the drawing board for future work. One is for the agent to understand the meaning of text. Balabanovic’s Fab [Balabanovic 1998] is an example of an recommender system that makes text associations effectively. As discussed in Section 3.3.2, this will begin with incorporation of the vector space model for text that he adapted from Salton’s IR. In the *CollageMachine* scenario, each interaction by the user with a media element constitutes a query. The query is formed by the vector of terms constituted by the element. In the case of images, this would be derived from the contents of the ALT text attribute which is part of the HTML image tag.

Another approach for computing relatedness of collage elements is to employ image similarity algorithms. Indeed, *CollageMachine* would be an excellent environment for forming visual similarity queries, as well as for interaction with their results. With multiple sophisticated weighting algorithms in place, defining their relative importance will be arbitrary. The usability tests indicate that a broad class of users may want to actually deal with these issues. That is, an interface which gives users control of the blending of weighting algorithms should be provided at that time.

The agent model should also be extended beyond a single session for a single user. This can take a number of forms. A persistent model for individuals would allow them to accumulate context and knowledge over time. Their sessions would grow richer, because they would not be starting from scratch. They would need some mechanism for adjusting the role of their aggregated model with that of the immediate session. That is, sometimes they will want to do something more like what they were doing before; other times, they will desire something newer, more distinct. Giving the user real control over the agent will require a substantial interaction design / visualization effort focused only on this component.

Model aggregation also raises the possibility of using data that reflects other user's interests. Other recommendation systems have shown that as its level of detail increases, this kind of data sharing works best in the cases where a community whose members have common interests, can be defined. [Ibid] An example regards the browsing habits of a research lab, with regard to their field. Again, ideally, the artifact will afford some control over the blending of personal and community models in the experience. The usability tests indicate that giving this kind of control to users is warranted. Development of this kind is very focused and specialized. If undertaken, such research would introduce nuance into the *CollageMachine* experience. Social and technological elements would be seamlessly integrated. Users would be given credit for being sufficiently interested in their experiences to learn. Through development of this level of sophistication, *CollageMachine* has the potential to change the landscape of the Web.

The agent is not the only functional module of *CollageMachine* for which future work is clearly suggested. With regards to visual design, one significant finding has already been produced – that of the Collage Visualization Grid, with its dynamic allocation of screen real estate based on weights. This is only a beginning. Currently, the grid looks at all space uniformly. Future work can impose several types of gradients onto the grid. One will pull more important elements to the center, and push less important ones to the peripherae. Animation is part of this refinement. Another will develop *conceptual foci*, drawing related elements closer to each other. Automated movement of collage elements must be careful to leave those that the user has moved where the user put them.

Interaction design also has room for refinements. One example will enable the user to access a profile of each media element without going to its web page. The profile, would include the source and hyperlink destination of a media element, expressed both as titles and as web addresses. I envision doing this with animation, triggered by rollover (after a delay). The profile animation would appear next to the element, as part of the collage. To graphically distinguish this profile from the colorful, rectangular media elements, it would be presented as a monochromatic rounded figure.

4.4. scenarios of CollageMachine use

CollageMachine was initially developed from a broad conceptual sense. Several distinct usage scenarios have emerged through the development process. Development moves to specific situations of use. Part of the thick creation of situated artifacts is identifying particular characteristics. In response to different environments, somewhat divergent features are created. The concept forks. Imagined and actual variants of *CollageMachine* take form.

In developing usage scenarios, one important aspect is the matter of on whose behalf is *CollageMachine* more directly provided. The artifact can be provided to reflect the interests of different actors in the Web browsing ecosystem. The actors, in this case, are differentiated by their role in the publication of Web content. The version currently available on the Web is oriented to serve people who browse content. *CollageMachine* could also be provided on behalf and through the aegis of content providers. The forms vary. Decisions about usage scenario will motivate the directions and goals of future research.

To the content browser, *CollageMachine* is a tool for browsing from an alternative perspective. The artifact can help the user access a wide range of content in a short period of time. When interests are triggered, the user will be stimulated to shift to more in-depth, conventional browsing. For these users, usability tests indicate that the aspect of the agent model which determines relatedness is the most critical for ongoing development. For more recreational usage, the collage visualization, itself, may prove key. An example would be to develop more interesting media treatments, such as alpha-blending, and shapes for elements other than rectangles.

The content browser would also benefit from the maintenance of a persistent agent model. Inasmuch as the model is nuanced, it will develop over time, providing the content browsing user with a richer experience. The prospect of storing persistent models for users raises privacy issues. Who would have access to these emerging profiles of user interest, and on what terms? Several business models are suggested. In one model, providing merchants, and advertising networks with this data would finance ongoing development efforts. Users would give up their profiles knowingly, in order to derive the benefits of the browsing experience. This is analogous to the placement of banner and popup advertisements in the typical Web browsing experience. Users who interact with Web ads, accumulate profiles with banner networks, such as Double Click and Avenue A. Ad servers use these profiles to serve them targeted ads.

Other business models could finance continued development of *CollageMachine* from the end-user content browser's point of view. In these scenarios, each user would maintain control of the data that makes up the agent model of her/his interests. As *CollageMachine* is greedy for bandwidth and processing power, high speed Internet service providers, and PC and microprocessor manufacturers could choose to finance ongoing development to catalyze their sales. Similarly, platform manufacturers could seek to gain a competitive advantage if they had some kind of exclusive distribution arrangement for integration. This model is weaker. Finally, end-users, themselves, could choose to buy or lease access. This model is generally not successful during this period of time. The typical Internet publisher model would be to use part of the presentation space for rotating banner ads. This model, while still popular, is also somewhat of an endangered species during the recent Internet downturn.

For content providers, *CollageMachine* can serve as an alternative means for presenting content. The artifact pulls content to users dynamically. In some scenarios, this could call for a much smaller visual footprint than the one utilized when the tool is deployed for end-users. Instead of taking the whole display, or close to it, *CollageMachine* could use a much smaller space. It could be integrated with static content elements. The most obvious application would be for catalog merchants. The user who is not clicking can still be exposed to a variety of wares. Shepard has shown that people are more able to recognize and recall images than text. [Shepard 1967] Similar studies could be setup to ascertain if a dynamically changing array of media elements is more likely to get users attention than a static configuration. It could also investigate how the unpredictability of indeterminacy effects user's attention and focus.

Content providers who deploy *CollageMachine* can integrate its model with user models from other sources. They can use these models to drive their presentation of content through other channels. An example would be server-side dynamic formulation of a Web site that appears static to the user.

Search engines are a special kind of content provider; they provide meta-content. The typical form of search engine results is discouraging to users. *CollageMachine* is valuable tool for visualizing search results. Searches are conversely an important method for seeding *CollageMachine*. Deliberate integration of *CollageMachine* with a search engine makes functional sense. Such integration can do even more than supporting the cleanup of the media element sets that make up search collages. As in the case of other content providers, a persistent version of *CollageMachine*'s agent model can be combined with the information retrieval model that derives from an individual search. Particularly in cases wherein a search returns many results, this will personalize the search experience for the user.

The significance of content provider perspective as a viable means to support ongoing *CollageMachine* development illustrates the role of brands in defining what the Internet is. *CollageMachine* has a certain hip gee whiz factor associated with it. Research and development is not simply a matter of technology, or of usability. The positioning of brands in the Internet ecosystem drives the production of sign values. This work, which began with a Dada impulse, cannot avoid that. Despite its meshwork impetus, the structure of the Web ecosystem could push *CollageMachine* to support hierarchy. This is similar to the current role of branded advertising in the distribution of "alternative" music. [Leland 2001] During 2000, Moby made $1 million by licensing the music on his current album to advertisers such as American Express and Nordstrom. My values will ultimately be represented in how I deal with positioning *CollageMachine* in the Internet ecosystem.

In addition to deployment on the behalf of content browsers and content developers, other aspects of scenarios differentiate appropriate situated forms of *CollageMachine*. The artifact can become directly involved in social processes which range beyond an individual user. These situations can be oriented toward work, toward play, or to transitional spaces. The position of *CollageMachine* in social interaction can involve multiple users concurrently accessing the same collage session through multiple computer + display instances. This would be implemented by a client-server or peer-to-peer architecture. Another type of shared scenario goes beyond the desktop to involve multiple users who sequentially access a single large display. Such an ambient scenario integrates the artifact directly into a real world social context, instead of creating a virtual one.

In one kind of virtual scenario, a loosely constituted online "community" would use shared collages to augment a chat environment. Or the use scenario can be more work-oriented. In response to a *CollageMachine* presentation, University of Calgary researchers have developed an independent implementation of a streaming collage browser for computer supported cooperative work.[Greenberg and Rounding 2001] Their Notification Collage employs a client-server architecture, based on Microsoft Windows ActiveX objects. Users can drag a wide variety of objects onto a shared collage space. The server broadcasts the position and state of each object to all connected users. The objects include instant messaging clients and video cameras. Web pages are represented as thumbnails instead of being decomposed into constituent media objects. Even though it is not part of the current Notification Collage System, decomposition of documents for CSCW would be beneficial, particularly in situations of collaborative document development projects.

The Notification Collage usage scenario includes both virtual social space created by multiple concurrent remote users, and an ambient display that is shared sequentially in physical space. The developers have conducted sustained informal demos, using their own lab as a subject environment. Sessions run on a large, shared display in a central foyer / meeting area, and also on the PCs of workers who are telecommuting. Not surprisingly, they report different kinds of interaction in the different usage contexts.

While some weight-based model apparently underlies that system, weights are not part of the data which is shared through the Notification Collage architecture. This contrasts somewhat with the JumboScope installation that I have been developing with a group of students at Tufts University over the past year. JumboScope employs a three-tier architecture. In JumboScope, media elements and references to Web pages are stored in an Oracle relational database (RDBMS). A middle tier, consisting of Java Servlets, serves several functions, as it stores elements in and retrieves them from the DBMS. Together, these tiers comprise a *media repository*. The process begins, as members of the community can submit media through a public, standard web browser based HTML form. Later, through a private HTML interface, members of the installation team can *curate* the media elements, accepting or rejecting them based on the University's decency policy. That interface also enables a curator to set a bias weight for the element. Concurrently, the media repository serves as a seeding source for collage sessions. Just as *CollageMachine* selects documents to deconstruct and media elements to display, the middle tier employs weighted random select to choose elements to seed a *CollageMachine* session. Again, the agent model is extended persistently, to the server.

The JumboScope system is focused on delivery of collages, formed from the media repository, to a large display in the lobby of a main campus building. When users interact with the collage in the public space, their interactions trigger the passing of messages back to the media repository. That server ensemble aggregates the expressions of interests by users over time at the installation. It stores this data in the RDBMS. The persistent user interest model then forms the basis for on-going collage seeding operations.

This public ambient situation differs markedly from the CSCW context. The activity of the users is play, not work. The artifact's serves to augment its environment intangibly by serving as a medium through which community members can share in a diffuse, unexpected way. Further, the "users"/audience in an open public space are a larger, more fluid ensemble. In the consistent, tight knit environment of a lab, members are definitely expected to know about the artifact, and to homogenously grow familiar, through actual interaction. In the public ambient environment, the audience is heterogeneous and not focused. Therefore, the interface has an especially great burden for making its interactive semantics clear to users. JumboScope will open next week. I look forward to gathering and analyzing usage data.

Other public ambient collage usage scenarios are imagined. Dynamic, interactive installations can replace static billboards in airports and other public spaces. Museums and site specific installations can use *CollageMachine* for presenting particular, curated media element sets. In these contexts, I will integrate interactive collages with other presentation forms. Public kiosks can use *CollageMachine* in ambient mode while awaiting interaction via other navigation paradigms.

4.5. users experience interface ecosystems

Users are discipline blind when they experience interfaces. They are enmeshed in complex webs of multidimensional relationships. They respond to immediate sensory perceptions. They do not isolate factors. They do not think, "oh, that is an algorithm," and, "this is graphic design." They bring their world views to the experience. That is, they are situated in layers of context. Some systems of representation feel more native to them; some feel more foreign. The art and the science are indistinguishable to the user. The immediate and the underlying mix. Either they get it, or they don't. Either it's satisfying, or it's a drag. They do not unpack sensory and contextual aspects. For example, as they experience *CollageMachine*, users respond seamlessly to aspects of the agent model, and to the design of the icons. Similarly, they don't stop to analyze the factors which have shaped their conception of the Internet, as they sit down to begin a session. Nonetheless, if we, as interface developers, want to understand the factors which influence them and ourselves, we must. Users experience interfaces as ecosystems. Interfaces present and invoke multidimensional border relationships. Myriad systems of representation meet and flux. Users experience the dimensional intersections from a single point. They are not responsible for forming the model. While they sit at the node where the immediate details meet the wide context, they do not map the interface ecosystem. Developers must take all of this on. If we want to thoroughly meet them in the middle, we who are developers must deliberately integrate and translate through the interfaces we make.

4.6. ecosystem models of collage and emergence in theory and practice

The triangular concept – context – design loop model allows development to proceed appropriately, without being unduly constricted by a single particular discipline. The modes and phases of cognitive circulation involve formal and informal methods. Scientific, ethnographic, and artistic practices are allowed to mix.. These models are meshworks. Their invocation enables development to proceed ecologically, just as the user experiences the resulting artifact as an ecosystem.

The triangular model was developed bottom up. It was distilled through the analysis of practice. It emerged as a blueprint for future ecological development of interfaces from consideration of my experience of *CollageMachine* development. This model represents interface ecology principles in the context of the process of developing interactive artifacts.

Collage has served as the fulcrum in *CollageMachine*'s development as a model of interface ecology. *CollageMachine* development pushed me to study collage. Collage is the process of recombining found objects to produce new meanings. The range of these found objects which can be subjected to collage in the information age extends to include any elements of representation, that is, of media, disciplines, and cultures. Collage principles operate in interfaces, through their function as border zones of juxtaposition. Collage situations stimulate interpretive processes of translation. As a recombinator, collage embodies non-linear dynamics. The composed whole derives its character from the interactions of components, rather than from their simple summation.

The intellectual trail from collage led to the creative cognition of emergence. Emergence is a phenomenon both of human cognition, and, more broadly, of the evolution of non-linear systems of components. Self-sustaining meshworks emerge from more loosely coupled sets. Interconnections between interface ecology as theory and *CollageMachine* as practice emerged through both through consideration and practice of collage and emergence.

The triangular concept – context – design loop results from reflection on interface ecology practice during *CollageMachine* development. The open process, which was bound neither to art nor to science, but freely combined them both, allowed my experience as a developer to be a playful one. The cognitive circulation model of human computer interaction development takes this process a step further. I developed this model by applying creative cognition principles to my own work as a collage and theoretical artifact producer, reflecting on the results of these applications, and comparing this reflection to generally accepted hci development models. This process intertwines strange loops of emergence.

Similarly, the aesthetic choice to use indeterminacy resonated on multiple levels. Through *CollageMachine*, my own stimuli were unpredictable, which helped to keep my thinking open. Indeterminacy brought attention to significant behavior's range of play and work. Users were also struck by this stimulus of *CollageMachine*. They are receptive to a great range of potential browsing experiences. Future research can focus more directly on exposing and developing a range of playful modalities of interaction with and through the Internet. We need to focus on what involves people, more than what makes them efficient. A development process which explores the range of life experiences which technology can support will be necessary for expanding that range. Usability is necessary, but far from sufficient. Because work is more than completing tasks efficiently, open exploration of deeper engagement in human computer interaction will also fundamentally effect the way interactive artifacts are used for work.

In addition to its openness in the invocation of disciplines, interface ecology takes the crucial step of connecting theory and practice. This approach contrasts dramatically with prevailing separations between disciplines that analyze, and those that generate. For example, performance studies does not include creating theater, dance, or music. Cinema Studies likewise excludes making films. The History of Science is insulated from its practice. These barriers resist the formation of energetic hybrids. Internet Studies moves toward replicating this dreary division. Interface ecology is a mutant strain. The ecosystem approach, by emphasizing relationships through methods such as collage, opens the floodgates to encourage the creation of myriad recombinants. *Making* gains dimension through the perspective of contextual awareness. Analysis grows more substantial through integration with creative practice. From both sides, the soup grows thicker. Students – who have not yet been trained to stay behind disciplinary walls – are hungry for this nourishment. Users will benefit from the resulting next generation interfaces.

Interfaces, thickly created, are situated components of their contexts of origin and development. Influence flows bi-directionally. Sign values circulate with scientific rules, aesthetics, and political positions. The interdependent relationships which evolve are the signature of ecosystem.

The extended interface form brings focus to the process of combining media, cultures, and disciplines. The strange loop of metadiscipline takes the process a step further by applying its objects and methods to itself. Interface is the pivotal form of practice and theory, a form that can both be observed and created. As environmental theater broke the theater's fourth wall, so with interface ecology the ivory tower is disassembled. Its components are redistributed. Their connecting pathways must traverse new boundaries.

Components of the theory of interface ecology and the *CollageMachine* application aggregate organically through my development process. Feedback across these pathways circulates ideas. Aspects of this ecosystem, including myself, personally, are transformed. These connections of theory, process, and product reflect the ecosystem form in practice. They constitute a working model.

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